AMHARA NATIONAL REGIONAL STATE
WATER ,IRRIGATION AND ENERGY BUREAU
(BWIE))

FEASIBILITY STUDY & DETAIL DESIGN OF AMTU INTAKE IRRIGATION PROJECT IRRIGATION PROJECT

AMTU IRRIGATION AGRONOMY FINAL REPORT

CONSULTANT:
AMHARA DESIGN & SUPERVISION WORKS ENTERPRISE

Amhara National Regional State

Water Resources Development Bureau

(BOWRD)

Feasibility Study and Detail Design
of
Amtu Intak Small-Scale Irrigation Project

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FEASIBILITY STUDY & DETAIL DESIGN REPORT STRUCTURE

- Volume I: Watershed Management
- Volume II: Engineering Geology
- **Volume III: Irrigation Agronomy**
- Volume IV: Engineering Design
- Volume V: Socio Economy
- Volume VI: Environmental Impact Assessment

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ACRONYMS

ADSWE	:	Amhara design and supervision works enterprise
ADO	:	Agricultural development offices
CEC	:	Cation exchange capacity
Cm	:	Centimeter
DA	:	Development agent
EC	:	Electrical conductivity
Ep	:	Project efficiency
ETc	:	Evapotranspiration of crop
ETo	:	Potential evapotranspiration
FAO	:	Food and Agriculture Organization
GIWR	:	Gross irrigation water requirement
Ha	:	Hectare
Hr	:	Hour
IPM	:	Integrated pest management
Kc	:	Crop coefficient
Kg	:	Kilo gram
Km/hr	:	Kilometer per hour
Lt	:	Liter
L/S/H	:	Litter per second per ha
LGP	:	Length of growing period
MASL	:	Meter above sea level
M/S	:	Meter per second
MM	:	Millimeter
M	:	Meter
Mt	:	Managment
NIWR	:	Net irrigation water requirement
NGO	:	Non-governmental organization
NMSA	:	National meteorology service agency
OC	:	Organic carbon
OM	:	Organic matter
PPM	:	Parts per million
QT	:	Quintal
RF	:	Rainfall
RH	:	Relative humidity
SWC	:	Soil and water conservation
Sec	:	Second
S/N	:	Serial number
UTM	:	Universal Transverse Mercator

1. INTRODUCTION

1.1. General

The Amhara national regional state has abundant land and water resources (surface and underground water) which can be used for irrigation development. It is also one of the major crop-growing regions in the country and contributes a lot for the domestic as well as foreign markets. However, due to climate changes and thereby uneven distribution and erratic nature of *Meher* and *Belg* rainfall as well as the recurrent drought occurrences, throughout the country in general and within the region in particular, rainfed agriculture has not been found a reliable means of crop production.

Irrigation scheme development plays vital role to increase crop production and productivity either by supplementary or full irrigation. It stabilizes crop production by protecting against drought and shortage of rain thereby increases crop yields and quality. And hence increases the income of farmers' and thereby improves their standard of livings. It also permits farmers to grow high value (cash) crops and crops that improve their diet. Therefore, development of irrigation projects, which is supported by effective research, strong extension and credit services, adequate and timely supply of agricultural inputs (such as: fertilizers, improved seeds, agro-chemicals and farm implements) is very indispensable to overcome the existing food shortage and other crucial needs. Of course, encouraging efforts have been done by governmental and none-governmental organizations to introduce irrigation developments, especially to the drought prone areas of the Region.

The present feasibility level study of irrigation development project has centered to Amtu Intake irrigation project . The area identified for the Amtu Intake irrigation project is located in the Eastern part of the Amhara Region, specifically in North Shoa Zone. The area which was estimated to be about a net command area of 100 hectares has recommended for irrigation development by constructing intake structure from the water source of Amtu river and using mostly earthen canals.

This study was carried out to introduce modern irrigation scheme in the study area by constructing intake structure from Amtu river . The study of Amtu Intake irrigation project was carried out by Amhara Design and Supervision Works Enterprise, ADSWE (Consultant), after an agreement has made with Amhara Region Bureau of Water Resources Development (BOWRD).

The present agronomy feasibility study report contains, in addition to the introduction, objectives and the study methodology, the project area profile, existing rainfed and irrigated crop production systems, existing agronomic practices, major crop pests and their controlling measures, inputs requirements and utilizations, proposed crops and cropping patterns, crop water requirements, irrigation duty, irrigation schedules, supporting services, recommendations and the like, which are required in the study report of Amtu Intake irrigation project. The feasibility study report also includes references and annexes (comprising supporting reports prepared for the agronomy study).

In general, the study report can serve as the baseline/guideline for the implementation and development of the AIW, particularly for agronomy part.

1.2. Objectives

The general objectives of the Amtu Intake irrigation project coincide with the objectives of the Ethiopian Water Resources Management Policy (EWRMP) and the Ethiopian Agricultural Development-Led Industrialization (ADLI) with regard to the irrigation sub-sector, namely:

- Development of small-, medium- and large-scale irrigation for food security and food self-sufficiency at the household and at national level as well as for producing industrial raw materials and crops for export.
- Promotion of irrigation project preparation and execution on the basis of acceptable socio-economic, technical and environmental criteria, according to the principles of sustainable productivity and affordability.
- Promotion of an efficient system of irrigation.
- Advance preparation and design of "ready-made" projects for immediate implementation.

The Specific objectives are:

- To study the existing physical features and agricultural situations in the study area /i.e. agro-ecology, land use, soil conditions, farming system, etc. /.
- To identity and assess the potential and main constraints in the project area.
- To assess the existing crop production situation (cropping pattern, crop calendar, etc).
- To assess the present situations, crops and level of production, cropping systems and rotations, and support services such as extension, finance and credit, research and development, level of agricultural inputs requirements and utilization, crop protection level.

- To propose the necessary interventions measures and thereby ensure the possible increase in crop productivity.
- To propose suitable cropping pattern and crop calendar with appropriate technologies.
- To compute and analyze the proposed crops water requirements and irrigation intervals for the proposed project area.

1.3. Scope of the Study

- Assessment of the present situation, including the physical environment, crops and level of production, cropping systems and rotations, and support services such as extension, finance and credit, and research and development.
- Provision of a plan for irrigated agriculture in the project area, including selection of crops for irrigation, crop make-up, irrigation methods, production methodology, and irrigated crop management systems, including overall aspects of production.
- Define the entire agronomic practices to be adopted in light of soils, topography, and all climatic parameters of the command area and recommend the best varieties.
- Identify the envisaged potential crop insect pests, diseases and weeds and recommend appropriate control measures.
- Workout net and gross crop water requirements (CWR), irrigation intervals and irrigation frequency based on soils of the command area.
- Calculating the proposed crops productivity in the project area is based on the current CSA crops productivity assessment for Amhara Region and local crop yield assessment data of Tamo Kebele and Asagrt Woreda.
- Specify and quantify the agricultural inputs required for producing one hectare of proposed crop.
- Evaluate technical and non-technical production constraints affecting full exploitation of the available resources.

1.4. Methodology of the Study

Agronomic survey was carried out in Asagrt Woreda, specifically in Tamo Kebele, during the month of April 2015. The field study was carried out through field observation, interviewing key informant farmers, primary and secondary data collection and conducting direct discussions with the concerned experts at kebele and woreda levels.

Primary data collection was carried out by interviewing key informants in the project area. Secondary data were also collected from the respective kebeles agriculture development office using prepared checklists. Moreover, discussions were made with the woreda agriculture development office, specifically with respective experts whom they concern, and the project kebele development agents (DAs).

Existing farming and cropping systems, agronomic practices, crop production constraints, farmers' inputs demand and utilization, credit access, etc, information were tried to be collected from the local farmers by using key informant interview method. In addition, physical observations and surveying of the project area (command area characteristics and soil survey) as well as direct measurements were made within the command area.

For Amtu Intake irrigation project study, Ginager station for rainfall and LocClim, 1.0 softer (FAO, local climate estimatorVer1.0) for climatic data estimation were used. Rainfall data were collected from the National Meteorology Service Agency (NMSA). The water requirements of the recommended crops were determined using a computer software program (Cropwat 8.0), which is used for irrigation planning and management that has developed by land and water development of FAO.

2. PROJECT AREA DESCRIPTION

2.1 Physical Features

2.1.1 Location

Amtu Irrigation Project is located in Tamo Kebele, in Asagrt Woreda, North Shewa Zone of the Amhara Region. The study area is found in the Amtu river valley about 8 km from the woreda capital town of Asagrt. , Ginager town has a distance of 140 km from zonal capital Debre Birhan. Total size of irrigable area is 100 hectares

Based on the Topo map developed from command area surveying data the command area elevation ranges from 2352 to 2363 meters above sea level (masl). The command area is located in between the extremes of 1035510 UTM Northing and 563879 Easting.

2.1.2 Climate

On the basis of the traditional Ethiopian Agro-Ecological Zones (MOA, 2001), Amtu Intak Irrigation Project, which is located at the vicinity of , Asagrt town, is basically classified as Wiona Dega (Moist tepid) agro-ecological zone that indicates rainfall distribution problem and poor moisture condition in the area. There is belg rain season in the project area but not adequate. Although Meher rain is considered adequate, there is notable variation in terms of onset, distribution and withdrawal of rain season from year to year affecting crop production and productivity.

Ginager meteorological station for rainfall and LocClim, 1.0 softer (FAO, local climate estimatorVer1.0) for temperature, relative humidity, wind speed and sunshine hour were used for the project study. In general, the source of meteorological data is the National Meteorology Service Agency (NMSA).

2.1.2.1 Rainfall

The project area has unimodal pattern of rainfall. The main rainy season (Meher/Kiremt) occurs from Mid June to Mid September.

In general, the rainfall of the project area is characterized by its variability in distributions. Consequently, the main bottle neck for successful crop production in the area is the nature of uneven distribution of rain fall. Meher/Kiremt rainfall is largely received in the months of June, July, August and

September. Had the annual amount of rainfall been well distributed throughout the rainy seasons, where meher crops are grown, the amount of rainfall may have been sufficient for the crops grown in the wet seasons.

Twelve years rainfall data was used for the computation and analyses of irrigation water requirements. The monthly total rainfall data recorded from 1995-2008 was analyzed. The average annual rainfall at , Ginager station is about 1806.25mm.

The monthly rainfall distribution (see Figure 1) has a unimodal or mono-modal characteristic with better rainfall distribution from June to September. More than 80% of the annual rainfall occurs from June to September.

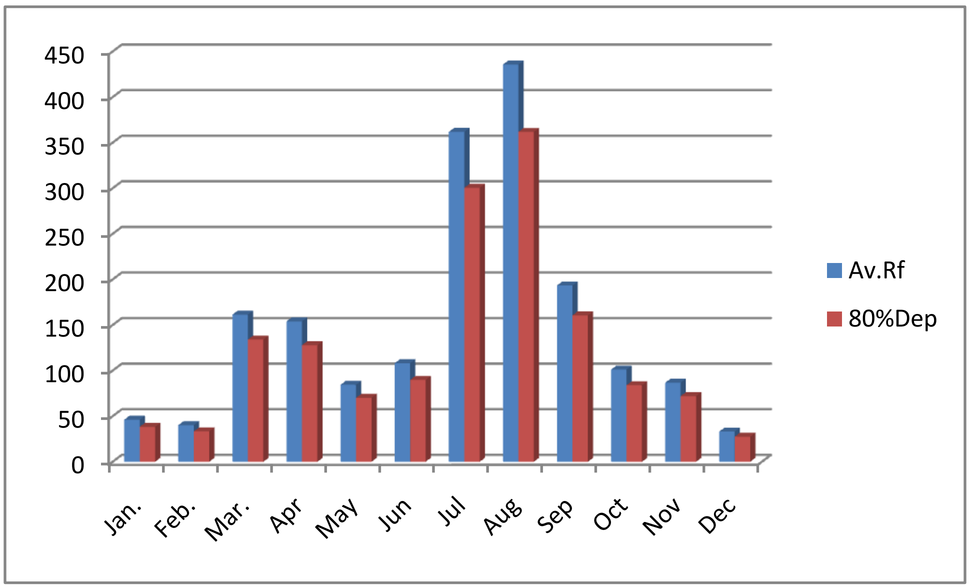

Figure 1: Average and 80% dependable rainfall at Shewa robit Station

The pattern of the seasonality of rainfall in the project area is determined by computing mean monthly rainfall ratio with that of rainfall module as rainfall coefficient according to Daniel Gemechu classification shown below:

Rainfall Coefficient	Designation /Represent/
<0.6	Dry (represent a dry season/month)
≥ 0.6	Rainy (represent a rainy season/month)
0.6 to 0.9	Small Rains (represent small rain season/month)
≥ 1	Big rains

1.0 to 1.9	Moderate (represent big-rains with moderate concentration)
2 to 2.9	High (represent big-rains with high concentration)
3.0 & over	Very high (represent big-rains with very high concentration).

Rainfall coefficient which is defined as the ratio of mean monthly rainfall to rainfall module (one-twelfth of the annual total) is shown in Table 1.

Table 1: Monthly and Dependable Rainfall and Rainfall coefficients

Month	Jan.	Feb.	Mar.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Av. Rf	46.1	40.2	161.4	154.0	84.5	108.2	361.9	435.6	193.4	101.1	86.7	33.2
80%Dep	38.3	33.4	134.0	127.9	70.2	89.8	300.5	361.8	160.6	84.0	72.0	27.5
Rf CV	0.3	0.3	1.1	1.0	0.6	0.7	2.4	2.9	1.3	0.7	0.6	0.2

Accordingly March, April and September represents Big rain with moderate concentration month; Whereas, May Jun, October and November represents small-rains season, July and August represent big-rains with high concentration rainfall. The rest (December, January and February) are known as dry months. Irrigation is required if crop production is envisaged in the long period of December to and Feburary.

2.1.2.2 Temperature

The prevailing temperature considerably influences selection of crops and their growing periods. Optimum temperature plays an important role on the growth period and the production of crops. The mean minimum and maximum temperature at Asagrt meteorological station is 13.2 and 25 ^{0}C, respectively. The monthly mean minimum temperature varied from 11.4 ^{0}C (Augest) to 15.5 ^{0}C (in May); and the monthly mean maximum temperature varied from 20 ^{0}C (August) to 27.5 ^{0}C (May). No serious frost period is experienced in the project area but sometimes hail damage occurs in the months of August and heavy floods and storms in the month of July (based on information obtained from DAs of Tamo Kebele).

2.1.2.3 Sunshine Hours Duration

The sunshine hours duration at , Asagrt ranges from 4.8 (July and Augest) to 9.3 hours/day (Jun). The mean annual sunshine hour duration is 8.0.

2.1.2.4 Relative Humidity

The relative humidity (RH) at , Asagrt also varies from 30% (Feburary) to 77% (August) and the mean annual RH is 45%.

2.1.2.5 Wind Speed

High desiccating wind in the form of storm not only increases crop water requirements, due to increased evapotranspiration, but also adversely affects the growth and yields of crops depending on the crops growth stage, at which it occurs. However, the wind speed at , Asagrt ranges from 1m/sec/d to2 m/sec which is low and not likely to cause damage to the crops. The mean annual wind speed is 2 m/sec.

2.2 Command Area Characteristics

2.2.1 Topography

Topography is an important factor for the planning of any irrigation project as it influences method of irrigation, drainage, erosion, mechanization, cost of land development, labour requirement and choice of crops.

The topographic feature of the far surroundings of the project area, especially in the –North and South a directions, is dominated by chains of mountainous escarpments. Nonetheless, the topographic feature of the command area slope is ranging from 2-5 %. The slope gradient class also ranges from nearly level (2%)). Hence, it has identified to be almost suitable for surface irrigation.

Figure 2: Partial view of Amtu command area

The project command area is situated at the right side of Amtu river from its natural flow direction; and the natural topographic feature has also inclined from South-West to North-East direction.

2.2.2 Land Use Pattern

The land use type of the command area is almost all covered by traditional rainfed and irrigated farming and cultivated lands of individual holdings. The total area of the kebele (2537ha), where the project site is found, the largest coverage is Grazing land which is 1000 hectares (39%); and the rest is covered by cultivated land, construction, gullies, etc. lands (see Table 2).

Table 2: Existing land use pattern of the project area

Land use type	Command area		Tamo Kebele	
	Area in (ha)	% cover	Area in (ha)	% Cover
Cultivated land	100	98.8	844	33.4
Grazing land	0	0.0	1000	39.6
Forest lands		0.0	0	0.0
Bush lands	0.125	0.1	300	11.9
Built up	1	1.0	260	10.3
Others (gullies)	0.125	0.1	123	4.9
Total	101.25	1	2527	100

Source: Tamo Kebele Agriculture Development Offices.

2.2.3 Surface Characteristics

As to the surface characteristics of the command area (i.e. stoniness, rock out crops, water logging, flooding, etc), there are some stones but no rock out crops in the command. This situation is suitable for full capacity of crop seedling emergences. soils of the command area are predominantly sand textured .seasonal water logging is a problem due to over flowing of the river, especially in wet seasons, and needs to employ river bund or drainage measures. Nevertheless, soils of the command area have deep characteristic and a workable soil depth for crop production.

2.2.4 Soil Characteristics

Soil properties (physical, chemical, etc.) greatly influence the growth and thereby yield of crops which is grown. As to the soil characteristics of the command area please see the soil feasibility study report.

2.2.4.1 Soil Physical Properties

a) Texture

Soil texture refers to the relative proportion of sand, silt and clay in a mass of soil. Texture is important in that it helps to determine the capacity of the soil to retain moisture and air as both are necessary for plant growths. Soils with greater proportion of large particles are well aerated and allow water to pass through the soil more quickly.

Based on field observ7ations and soil laboratory results, from soil samples collected from command area and submitted to ADSWE soil lab, the command area has predominantly sand textured.

Effective soil depth

According to FAO, soil depth is categorized as follows:

Very shallow	< 30 cm
Shallow	30 – 50 cm
Moderately deep	50 – 100 cm
Deep	100 – 150 cm
Very deep	> 150

The effective soil depth of the command area was measured during field working period; and hence, most of the study area soils are categorized as deep to very deep soil (≥ 1 meter).

Table 3: Summary of physical and chemical analysis of soils of the command area

Soil auger composite sample	Depth (cm)	% Sand	% Clay	% Silt	Textural Class	pH (H_2O) (1:1.5)	ECe, (dS/m)	% C	% OM	% N	Ava. P (ppm)
A_1	0-20	40	22	38	Loam	5.64	0.05	2.3	3.97	0.2	42
A2	20-50	34	24	42	Loam	6.03	0.06	2.7	4.54	0.2	58

Note: Soil laboratory report shows that the command area soils are loam textured.

2.2.4.2 Soil Chemical Characteristics

a) Soil Reaction (pH)

The pH of soils can provide overall information of soils condition for crop growth and for crop selection. For these purposes soils reaction was measured in a 1:2.5 (H_2O) soil suspension.

Table 4: General rating for soil pH

Rating	pH	General Interpretation
Very high	>8.5	Ca and Mg unavailable, may have high Na, possible B toxicity otherwise as below
High	7.0-8.5	Decreasing availability of P and B above 7.0 increasing liability of deficiency of Co, Cu, Fe, Mn, Zn.
Medium	5.5-7.0	Preferred range for most crops
Low	< 5.5	Acidic soil. Possible Al toxicity and excess Co, Cu, Fe, Mn, Zn. Deficiency in Ca, K, N, Mo, P, S

The pH values of soils of the study area ranges from 5.54 to 6.03 for pH (H_2O) soil suspension test in the top 0-50cm soil depth. Based on soil Lab results (Table 3) and pH rating (Table 4), the pH of the command soil is predominantly found at a medium level. Hence, soils of the command area are suitable for most of the selected crops to be grown. In general, most crops grow satisfactorily on soils with a pH ranging from 6.2 to 8.3. Where, soils with a pH of 8.3 or greater than these values usually have high sodium contents. Conversely, soils with a pH below 5.5 are strongly acidic soils and limit the availability of essential elements (N and P).

b) Electrical Conductivity (ECe)

The best method for assessing soil salinity is to measure the electrical conductivity of the saturated soil extract, the ECe. Salinity effects on plants, as measured by the electrical conductivity of the saturated extract, ECe, in decisiemens per meter, dS/m, are indicated in Table 5.

Table 5: Electrical conductivity expressed in dS/m

Rating	EC (dS/m)	Crop Reaction
Non-saline	< 2	Salinity effects mostly negligible
Slightly saline	2- 4	Yields of very salt-sensitive crops may be restricted
Moderately saline	4 – 8	Yield of many crops restricted
Strongly saline	8 – 16	Only salt-tolerant crops yield satisfactorily
Very strongly saline	> 16	Only a few very salt-tolerant crops yield satisfactorily

Source: Based on Fundamentals of Soil Science, 8th Edition.

The effect of salts on plants is mainly indirect, that is, the effect of salt on the osmotic water potential. Decreasing water potential due to salt reduces the rate of water uptake by roots and germinating seeds.

Based on the soil lab result (ADSWE, 2015), soils of the command area has ECe values ranging from 0.05 to 0.06 dS/m, which indicates a non-saline effect on the selected crops as presented in Table 3 and 5.

Nitrogen

The general rating for the total nitrogen according to the Kieldahl's method is as follows:

Table 6: Interpretation of total Nitrogen

N (%)	Rating
> 1.0	Very high
0.5 - 1.0	High
0.2 - 0.5	Medium
0.1 - 0.2	Low
< 0.1	Very low

Total nitrogen values of the command area soils are 0.2 in the top 0-50cm soil depths, which predominantly indicates medium level of N in the soil profile. Thus, N source fertilizers response is high (See Table 3 and Table 6).

c) Available Phosphorus

Available phosphorus (P) has been determined by the Olsen method of bicarbonate extraction.

Table 7: Interpretation of phosphorus by Olsen's method

Available P (ppm)	Value	Comment
> 15	High	Fertilizer response unlikely
5 –15	Medium	Fertilizer response probable
< 5	Low	Fertilizer response most likely

Soils of the command area have showed high available P values. The available P range for the command soil is from 42 to 58 mg/kg or PPM in the top 0-50cm soil depths. Therefore, the soil lab result has indicated that soils of the command area are predominantly high in available P and hence P source fertilizers response is unlikely (Table 3 and Table 7).

d) Organic Matter (OM) and Organic Carbon (OC) Content

Organic matter is a good reserve for plant nutrition. Almost all life in the soil is dependent on OM for nutrients and energy. The importance of OM for plant growth is so vital. The primary or original source of soil OM is the production of the primary producers (the higher plants). This organic material is subsequently consumed and decomposed by soil organisms. The result is the decomposition and the accumulation of OM in soils that has great diversity and a highly variable composition.

During decomposition of plants and animals residues, there is a loss of carbon as carbon dioxide and the conservation and reincorporation of nitrogen into microbial products, which eventually are incorporated into humus. As a consequence, humus contains about 50-60% carbon (C) and 5% nitrogen (N) producing a C: N ratio of 10 or 12 to 1. The more decomposed the humus is the lower or narrower will be the C: N ratio. Humus is a good source of biologically available nitrogen. Humus is also a significant source of sulfur and phosphorus.

Based on the soil lab results, soils of the command area OC content ranges from 2.3% to 2.7% (average 2.5%) in 0-50cm soil depths, which indicates at medium contents of OC; whereas the OM content ranges from 3.97% to 4.57% (average 4.27%) in the same depths of soils, which is indicating predominantly medium contents of OM (Table 3 and 8). The ratio of OC to OM content, for soils of the project area, is nearly 1:1.76, which is in the optimum ratio and this ratio can also match to that of FAO's. According to FAO, the optimum ratio of OC to OM content is 1:16–2.

Table 8: Interpretation of OM and OC contents

Parameter	Range	Rating
Organic matter (%)	>6	Very high
	4–6	High
	2–4	Medium
	1–2	Low
	<1	Very low
Organic carbon (%)	> 20	Very high
	10-20	High
	4-10	Medium
	2-4	Low
	<2	Very low

2.3 Vegetation Cover

Based on information obtained from Tamo Kebele DAs, the major trees naturally grown and/or artificially planted in the kebele are: Warka, Shola, Kikira, Gumero, Wonbela, Dokima, Denbeka, Girar, and Bisana. Bushes are: Atat, Girar, Kimo,Agam, etc. Shrubs: Azo Areg, Serk Abeba, etc. Generally, the command area is presently used for to grow annual crops, grazing land and bush lands.

2.4 Water Resources

One perennial river, Amtu , are found in the project area come from North-East direction and flow towards North-West direction .

Traditional irrigation practices are being tried to be carried out in the project area from Amtu Rivers, presently both have 5.375 hectares coverage. Amtu river , which is under study, is targeted for the present intake irrigation scheme from the upstream site. This will be put into effect by diverting water from Amtu river and conveying water with gravitational system through earthen canals to the command.

3. EXISTING CROP PRODUCTION

All the households, in the project area, are dependent on subsistence agriculture where the average productivity has been substantially decreasing due to different constraints particularly bad weather conditions, serious crop pests attack, very low level or lack of use of modern technologies and other problems.

To identify the agricultural production constraints and propose the mitigation measures, specifically to identify the short fall of crop production, a field survey was carried in the month of April, 2015. Through investigation of the farming systems and socio-economic aspects of the project area, it has tried to select appropriate crops and technologies with improved management practices for Amtu Intak Irrigation Project.

3.1 Rainfed Crop Production

3.1.1 Land Tenure, Farm Size, Draft-Power and Labour

a) Land Tenure and Farm Size

Land belongs to both the government and the individual farmers in the region in general and in the project area in particular. The average farm-land holding size of Tamo Kebele households (HH) is 2 hectares; and sometimes uses fallowing system as they have relatively better size of farm-lands in the project area. Almost all the HHs in the project area has fragmented farm-lands on average 3 in numbers (based on information obtained from Tamo Kebele development agents, DAs).

Having farmlands at different locations is considered by the local farmers as a good opportunity. That is because of risk aversions, like hail damage, flood injury, flood damage, land sliding and also from the aspects of getting productive, fertile and irrigable farmlands. However, fragmented farmland holdings are not suitable for proper time utilization, as it reduces the efficiency of farmers.

The individual households' average farm-land holding size is decreasing through years owing to population number increases, especially in the rural areas. In such situations, to satisfy the needs of additional food requirements, crop yields has to be increased by employing intensification approaches through the application of irrigation water, use of appropriate farm managements and introduction of improved farm-land inputs including farm implements as well as employ better cultivation techniques.

b) Draft-Power and Labour

In the project area, oxen are the only source of draft-power. The total numbers of oxen and households found in the kebele where the project is found are 908 and 730, respectively. Of the total HHs found about 100HHs are oxen-less .(based on data obtained from DAs of Tamo Kebele).

Farmers, who have no farm oxen, grow crops using a traditional renting agreement, that is, by renting their farm-lands to those who have oxen; and hence the produce is shared equally between the land renter and the sharecropper (without consideration of inputs cost incurred by the sharecropper). All the inputs and labour costs are covered by the sharecropper. The other option is getting oxen-power by providing the straw or grass of the produce for oxen owners. Another is by exchanging the Labour-day by the oxen-day (2:1 ratio), and the most old fashioned is begging oxen-power from their relatives or friends.

In the project area, during crop production processes, when farmers face a problem of shortage of labour they do not use hired labour, rather group working system is commonly practiced. The group of farmers usually works together for each one of the group member turn by turn and such system of working is common in the area. Such group working type is locally called 'Debo' or 'Wonfel'. The major agricultural activities and time where community labour are needed and used are during crop planting (especially for teff planting, weeding, harvesting, and threshing). The existing labour and oxen requirements of the project area for various farm-operations and major crop types on one hectare basis are presented in Table 9.

Table 9: Existing labour and oxen requirements for major crops and various farm operations

Crop type	Man & Oxen	Land Preparation	Sowing	Weeding & cultivation	Irrigation	Harvesting	Threshing & transport
Wet season							
Wheat	M	12	12	60		32	16
	O	24	8				28
Barely	M	4		40	16	16	8
	O	8					24
Faba bean	M	4	4	36	24	16	12
	O	8	8				20
onion	M	4	4	20		12	12
	O	8	8				20
Garlic	M	4	4	20		12	12
	O	8	8				20
Carrot	M	8	12	60	24	24	40
	O	16					
Lentil	M	12	32	136	24	100	
	O	24					
Fenugreek	M	12	60	136	24	60	

	O	24					

M = Man-days O = Oxen-days

Source: Tamo Kebele & Asagrt Woreda Agricultural Development Offices.

3.1.2 Existing Cropping Pattern

The rainfed agriculture is mainly based on summer (Kiremt) rainfall. In the project area rainfed cropping season starts commonly from the month of July to Mid September. During this time of span some crops are grown despite the fact that there is moisture stress or rain shortage frequently towards the end of the rain season. The cultivated land coverage by different crops (cropping pattern) varies from year to year especially depending on climatic factors (typically due to early or late start of the kiremt rainfall). Furthermore, farmers' preferences, soil conditions, market price situations and feed habit of the society also determine the cropping pattern. Sorghum, teff, barely, faba bean, wheat are the major crops grown, in the project area, during rainy season. Wheat, teff, barely and onion are grown in the dry season and are used, most of the time, for home consumption and market purpose .

At kebele level, where the project area is found, sorghum is the leading crop in area coverage having a share of 36% and followed by teff, faba bean, barley and wheat respectively (Table 10).

Table 10: Existing cropping pattern and production (rainfed) of Tamo Kebele, 2015

S/N	Crop type	Cropped Area		Productivity (qt/ha)	Production (qt)
		(ha)	(%)		
	Meher				
1	Teff	194	23.0	14	2716
2	Faba bean	120	14.2	20	2400
3	Wheat	83	9.8	21	1743
4	Sorghum	304	36.0	20	6080
5	Barely	143	16.9	35	5005
	Total	844	100		17944

Source: Tamo Kebele Agricultural Development Office

3.1.3 Cropping System

Following is the practice of leaving land un-cropped for periods of time to accumulate and retain water and mineralized nutrient elements. Nonetheless, because of population number increase and the rising demands of agricultural lands, fallowing is not practicing in the project area.

Crop rotation is the common cropping system being carried out in the project area. Farmers of the project area usually rotate cereals with cereals (Table 12). Cereals with pulses rotation is a common practice in the project area .

Table 12: The existing crop rotation patterns of the project area

Meher Season (1st)	Meher Season (2nd)
Teff	Wheat
Sorghum	Teff
Wheat	Faba bean
Faba bean	Teff/Wheat/barely
Barely	Faba bean

Source: Tamo Kebele Agricultural Development Offices.

Intercropping: no intercropping is commonly practiced in the project area.

3.1.4 Agronomic Practices

In simple terms, agronomic practices include tillage, land preparation, planting, weeding and/or cultivation, harvesting and threshing (Table 13 and 14).

3.1.4.1 Pre-Harvesting Practices (Land Preparation, Sowing, Weeding, etc)

In the project area land preparation commenced from land clearing that is clearing of shrubs, weeds and plant residues. The highest frequency of ploughing (3 times) is done for teff and horticultural crops like head cabbage, onion, potato, etc. (Table 13).

Sowing for almost all crops is done by broadcasting. Row planting is being practiced for horticultural crops (like head cabbage, onion, garlic, etc). For teff farmers sow the seed after the final plow but trembling by animals to make the land surface smooth is almost being ignored. All other crops, such as teff, wheat, barley, faba bean, etc are broad casted and then under ploughed.

Weeds are well known menaces for yield reduction in the project area. Hand weeding is the common practices that carried out in the project area for most crops, teff, wheat, barley, faba bean, and lentil. And hand weeding with the help of digging hoe is practiced for horticultural crops (Table 14).

Weeding and/or cultivations are done by men and women including families who have reached for working. The frequency of weeding activities for major crops varies from 0 to 3.

Table 13: Existing crop production schedule/crop calendar for the different farming activities

S/N	Crop type	Land preparation	Sowing	Weeding /cultivation	Harvesting	Threshing
I	**Rainfed**					
1	Barely	Apr-jun	Mid Jun-Earely Jul	Aug-Sep	Oct-nov	Oct-nov
2	Teff	Apr-jun	Mid Jun-Earely Jul	End Jul-Sep	Dec-end dec	Dec-end dec
3	Wheat	Apr-jun	Mid Jun-Earely Jul	Aug-Sep	Oct-nov	Oct-nov
4	Faba bean	Apr-jun	Mid Jun-Earely Jul	Aug-Sep	Oct-nov	Oct-nov
II	**Irrigated**					
7	Barely	Dec-end dec	Janu-Mar	Mar	May-Jun	May-Jun
8	Onion	Oct-nov	Janu-Mar	Mid Janu-May	Mar-Apr	
9	Wheat	Oct-nov	Janu-Mar	Mar	Mar-Apr	May-Jun
10	Head cabbage	Oct-nov	Janu-Mar	Mid Janu-May	Mar-Apr	

Source: Tamo Kebele Agriculture Development Office.

Table 14: Existing land preparation and weeding frequencies

S/N	Crop type	Frequencies of Ploughing	Weeding and/or cultivation
I	**Rainfed**		
1	Barely	4	2
2	Teff	5	3
3	Wheat	4	2
4	Faba bean	1	4
5	**Irrigated**		
II	Barely	**3**	**1**
6	Onion	3	4/with hoeing
7	Wheat	3	1
8	Head cabbage	5	7/with hoeing

Source: Tamo Kebele Agricultural Development Office.

3.1.4.2 Post-Harvesting Practices (Harvesting, Threshing, Storage, etc)

Harvesting and threshing are the most labour intensive and time consuming operations and are done in a traditional manner in the project area. Harvesting is practiced with the help of sickle for teff, wheat, barley and faba bean crops; for onion and garlic with the help of digging hoe; and for pepper and tomato with hand picking.

Cereal and pulse crops are left on the ground for some time to get dry after harvest and piled up for a while (from one day up to 2 month).

Threshing is done after a threshing ground has selected, marked in ring form, escarped, cleaned, sprinklerred with water to get compact, and then after a mass of mud is prepared with teff straw mix at the centre of the threshing ground and later plastered with the prepared mud for particularly the threshing of teff crop on it. For maize threshing is mostly done by hand manually. Crops teff, wheat, barley and faba bean, and are threshed on the prepared ground and threshing is done using oxen only, by trampling on it; and farmers continuously turn the straw with hand and with the help of wooden forked tools having two finger locally called "*Mensh*", to get the panicles exposed to oxen hooves and the grain to get loosen and separated from the panicles.. For teff, barely and wheat they use piece of oxen forehead skin, locally called "*Maragebiya*", to separate the chaff from the grain.

After cleaning the grain from chaffs the produce is mostly packed by plastic bags (*Madaberia*) and transport to home for storage by loading on donkeys' back. In the project area the produces are stored in different storage structures. Teff are commonly stored in *Gottera* locally called "*Sherfa*". The storage structures, *Sherfa*, are placed in door while Gota is placed indoor. The size and capacity of the different storage structures varies from farmer to farmer.

Regardless of the types of structures used and the precautionary measures taken, the overall annual losses of stored grains (by rodents, birds and insect pests like weevils) are high. As studies suggested, by FAO and others, the losses due to poor storage is estimated to be as high as 15–20% of the stored grain.

3.1.5 Input Use

Of the many the agronomic practices only some of are adopted by the local farmers. Though the recommended rate of compost application is 80-120 quintals per hectare, only about 255m^3 of compost was prepared by 28HHs and applied on 10 hectares of land in Tamo Kebele in 2015 (based on data obtained from DAs of Tamo Kebele). In general, compost and manure preparation and utilization is on the way of adaptation by the local farmers.

Some of the inputs that are being distributed in the area are fertilizers, improved seeds, agro-chemicals and farm tools. The inputs' distribution data in 2014/15cropping year in Tamo Kebele are presented in Table 15.

Table 15: Inputs used in the project area in Meher, in 2015 cropping year

Types of Inputs	Unit	Quantity used	Variety
		Tamo Kebele	
Soil fertilizers	Qt		
DAP	"	180	
UREA	"	180	
Lime	"		
Bio-Fertilizer	kg	Na	
Improved seeds			
Barley (malt)	"		
Agro-chemicals		**Na**	
Insecticides	lt		
Herbicides	"		
Fungicides	"		
Farm tools		**Na**	
BBM (cumulated)	No		
Tie Ridger	"		
Water pumps	"		
Geo-membrane (lined)	"		
Drippers (farmers level)	"		
Pedal pumps	"	0	

Na=data not available

Source: Tamo Kebele Agriculture Development Offices.

Based on data obtained from Tamo Kebele DAs and information gathered from local farmers, artificial fertilizers are applied for wheat and onion crop only. Furthermore, use of improved seeds (such as wheat) is not in an encouraging situation. Based on interviewed local farmers and DAs of Tamo Kebele explanation, the major constraints for farmers' low level of inputs utilization is that due to farmers' believe that their land is fertile, the high pricing of inputs, no timely supply of inputs (late arrival), and demand based supply of inputs is not practiced. In the project area, no private traders are available which can distribute herbicides and insecticides.

3.1.6 Crop Protection

Every year a significant amount of crop yield is lost due to crop pest infestation. In the project area there are economically important insect pests, weeds and diseases of crops. Cut worm, grass hopper, aphids, shoot fly, termites, and weevils (in storage) are some of the most important insect pests causing extensive damages to different crops (See Table 16).

Table 9: Common insect pests and crops infested

S/N	Insect pests		Crops infested
	Common name	**Scientific name**	
3	Cut worm	Agrotis segetum	Onion
4	Shoot	Delia sp.	Teff
5	Grass hopper	Different spp.	Teff
6	Termites	Different spp.	All crop types
7	Barely flay		Barely.

Source: Tamo Kebele Agricultural Development Office.

Weed floras are also known to cause great crop yield reduction. The name of major weeds of the project area and crops infested are shown below in (Table 17).

Table 17: Major weed species and crops infested

S/N	Common Name	Scientific Name	Craps infested
1	Striga (*Akenchira*)	Striga hermontica	teff
2	Dodder	Cuscuta spp	All crop
4	Mexican popi	Argemon mexicana	All crops
5	Torn Apple	Datura stramonium	All crops
6	*Aluma (*Amharic*)*	Amaranthus hybridus	All crops
7	Purpl Sedge	Cyperus rotundus	All crops
8	Coach Grass	Cynodon niemfuensis	All crops
10	*Engicha (local)*	Syprus spps	All crops
11	*Mech (local)*	Gizocia scabra	All crops

Source: Tamo Kebele Agricultural Development Office.

Some of the common crop diseases that are identified and do cause crop yield reduction in the project area are smut disease (sorghum), root rot (onion, pepper). Farmers in the project area do not have the concept of crop diseases and they relate it with insect pest effects. Hence, they do not practice control measures deliberately.

3.1.7 Supporting Services

a) Agricultural Extension

Like other kebeles of the region, agricultural development office has already established in the project kebele; and three professional (crop, natural resource and animal sciences) development agent are assigned in the project kebele to provide agricultural extension services and trainings to the local farmers.

The DAs have close and day to day contacts with farmers within the kebele and are responsible to implement the different agricultural programs and technology packages at the grass root level. Furthermore, the project kebele has divided into 3 sub-kebeles; and each DA has assigned to work agricultural extension activities in his/her sub-kebeles. Of the three DAs only one of them are assigned to act as manager for 2 consecutive years at kebele level. The managerial position is transferable to other DAs after 2 consecutive years of services in a round fashion.

One supervisor, 1 for 3 kebeles, has assigned to provide technical supports to DAs and to execute monitoring & evaluation activities on their daily agricultural extension activities. One animal health technician and one land use and land administration experts have assigned for the project kebele to work and provide agricultural extension services with their respective professions. Moreover, one cooperative expert has assigned to work in the project area (1 for 3 kebeles).

The woreda agricultural development office also closely providing technical assistances to DAs, supervisors and other experts who are assigned at kebele level to work with the farmers.

Regional Agriculture Bureau and Zonal Agriculture Department also provide agricultural extension services and working directions to the woreda agricultural development office and others who are working at the grass root levels. Besides to this the zonal and regional SMS team at both levels supports the woreda agricultural development offices and others.

Although the objectives of construction of farmers' training centers (FTC) in every kebeles is to train and capacitate farmers, on improved and modern agricultural technologies and packages' application by demonstration (for 3 or 6 months), the FTC site has not still started delivering the training services.

The current and flourishing approach for the dissemination of agricultural technologies to farmers, within the region in general and the project area in particular, is scaling up. This approach is mainly focused on the addressing of best agricultural practices that were tested and/or exercised by few farmers before. Thus, the previous minimum and family packages approach are now dropped and scaling up type of approaches and strategies are now being practiced at all levels (i.e. region to kebele levels).

b) Research

During the field survey it has assured that adaptive researches or demonstration trials are being carried in and around the project area .Diffusion levels of new technologies within the woreda in general and the project area in particular are not at satisfactory levels as the trial has started recently. In general, there are no strong Research-Extension-Farmer linkages in the area.

c) Credit

Amhara Credit and Saving Institute (ACSI) and Co-operatives are the major credit suppliers found in the area. ACSI is working at woreda level (Asagrt town) and cooperatives are working at kebele level. However, the amount of credit supplied and the timeliness of the credit to be supplied are not sufficient enough to satisfy the credit needy farmers.

3.1.8 Major Constraints of Rainfed Crop Production

Although the project area is food self-sufficient, crop productivity for most of the annual crops is low as compared to the national and the regional average. Based on the local farmers, who were interviewed during field study period, and the group discussions made with the respective woreda agricultural development office's staff and DAs of the project kebele, the major constraints for the growth of crop production and productivity are pointed out as indicated here below:

- Moisture stress due to uneven distribution especially during the starting and withdrawal of Meher cropping season (late rain start and early withdrawal) of rainfall.
- Very low level of input utilization (fertilizer, improved seeds, etc) of the local farmers.
- Development of deep rooted dependency syndrome among local farmers
- Poor soil fertility and use of low amount of fertilizers per hectare basis by local farmers
- Lack of awareness about utilization of new and improved technologies among the local farmers.
- Insufficient crop protection measures/practices at field level and post-harvest stages.
- No or low level of composting and manure utilization practices of local farmers.
- Shortage of farm-lands and poor farming practices of farmers.

- Lack of good quality agro-chemicals (e.g., insecticides) and sprayers supply.
- Low level of credit facilities to purchase agricultural inputs (e.g., fertilizers, improved seeds, etc)
- Crop diseases problem (onion root and bulb rot, pepper root rot and fruit wilt).
- Slow Development of Agricultural Research and existence of poor linkages among Research-Extension-and farmers.
- Flood and storm hazards coming from upstream hillsides and high land areas in wet season.

3.2 Existing Irrigation Practices in the Project Area

The pressure of survival and the need for additional food supplies to meet the demands of the increasing population is necessitating a rapid expansion of irrigation scheme throughout the world. Thus, irrigation is becoming a basic part of well developed agriculture throughout the world.

3.2.1 Cropping Pattern and Crop Production

As other parts of the region, irrigated crop production is being practiced in the project area by constructing traditional irrigation structures and modern technology or water pumps from Amtu and Asagrt Rivers.

Figure 3: Partial view of traditional irrigation practices carried out in Tamo Kebele

Concerning the irrigation development supporting services, as other woredas of the region, Irrigation and Drainage Work Process has already established under Asagrt Woreda Agricultural Development Office. Although no irrigation & drainage expert has assigned for the project kebele three development agents are already assigned in Tamo Kebele, where Amtu Intak Irrigation Project is found, to support farmers in whole agricultural extension services.

3.2.2 Major Constraints of Irrigated Crop Production

The major constraints in the traditional irrigation system, for crop production and productivity, as suggested by farmers and experts are:

- Although large rivers are found within the woreda and kebele they are located in gorges and are difficult to take out and utilize those rivers using water pumps or to divert.

- Insufficient utilization and wastage of irrigation water due to poor conveyance structures and unwise utilization
- Lack of agricultural inputs (seeds like garlic; onion fertilizers, chemicals, etc) supply for irrigated crops in dry seasons other than left over inputs
- Crop diseases problem (Garlic root rot, blight).
- Prevalence of crop diseases (garlic bulb rot, etc) and insect pests damages on different crops.
- No different agricultural inputs supply and high cost of inputs (fertilizers, improved seeds, agro-chemicals); and no timely supply of agricultural inputs, including fruit seedling suppliers
- Poor or lack of awareness among farmers of the project area on the use of modern technologies and inputs.
- Frequent damage occurrences on water pumps due to lack of wise uses
- Existence of poor agricultural extension and training services.
- Existence of poor or no linkages among research-extension-farmers
- Market price declines when production is produced simultaneously.

4. THE IRRIGATION PROJECT

4.1 Project Rationale and Objectives

Due to unreliable nature of Meher rainfall (uneven distribution), crop pests and diseases problems, etc, farmers of the project area are suffering from low income and poor standard of living. The importance of reversing the current situation is appreciated by the concerned federal and regional governmental bodies and by farmers of the project area. For the above reasons, the development of Amtu Intak Irrigation Project is so vital with the integration of improved agronomic practices.

Hence, the present irrigation project would contribute towards the supply of food and cash crops in the project area for the people that are suffering from very low standard of livings. It can secure the income of the people from double cropping system (harvesting twice in a year). Consequently, food self-sufficiency could be assured and household incomes would be improved.

Implementation of Amtu Intak Irrigation Project, therefore, aimed at increasing crop yields through wider application of agricultural inputs and use of irrigation water from Amtu river on a net command area of 100 ha (100 ha in wet season +100 ha in dry season through double cropping).

Amtu River is expected to solve shortage of rainfall thereby enables double cropping so that increases crops production in the area. For this irrigation scheme, the water harvesting structures proposed to be constructed are high-powered water pump and pumped-water conveying earthen canals to command area.

The main objectives of Amtu Intak irrigation project are:

- ≡ To increase crop yields through double cropping system and better use of agricultural inputs in a sustainable farming system among the beneficiary households in the project area.
- ≡ To bring about sustainable development of the farm families in the project area as a result their farm incomes would be increased from food and cash crops.
- ≡ To reduce the risk of crop production and productivity by minimizing moisture stress and crop pests problem through the use of modern crop protection technique in the area of irrigation.

4.2 Crop Production Development Plan

4.2.1 Crop Choices/Selection

Choice of crops has already been made based on the suitability of the soils (physical and chemical characteristics); adaptability to the prevailing climate (rainfall, temperature, altitude and other climatological aspects); food and economic values, farmers preference and experience in the production of the crop; Irrigation characteristics of the crop; and finally marketability and potentiality for agro-processing. On the basis of these factors, suitable crops were selected for both wet and dry seasons. Farmers of the area are well acquainted with most of these crops. The selected crops for Amtu Intak Irrigation Scheme, in both dry and wet seasons, are presented in Table 20.

Table 20: Cropping System (Wet and Dry Seasons)

Crop Type	Wet Season	Dry Season
Cereals	Wheat, Faba Bean, Barely	
Pulses		Fenugreek, Lentil
Oil crops	…………..	…………
Spices	…………	
Vegetables	…………	Onion, Carrot, Garlic
Fiber crops		
Fruit crop		

4.2.2 Cropping Pattern and Crop Calendar

Cropping patterns are proposed on the basis of crop mix and area coverage of individual crops. Crop diversification has been taken as a basic criterion in establishing the crop mix and area coverage. The introduction of various crops into the cropping pattern is assumed to widen the economic base of the project and minimize the risks associated with the growing of a single or limited number of crops. It is also very important to keep under continuous review the introduction of other crops both for use in rotation as well as alternative crops under certain circumstances.

The cropping pattern, which shall be dominated by annual food crops, is assumed to cover an annual cropping intensity of 200% (i.e. wet season 100% + dry season 100%). Cereals (Wheat, Barely) will cover the major part of the area followed by pulses(Faba Bean) in wet season; and vegetables (Onion, Carrot, Garlic), and pulse (fenugreek, lentil) in dry season. The percentage and area coverage of the crops to be grown annually, in wet and dry seasons, has shown in Table 21.

The planting dates have been set up based on the agro-climatic conditions and local experiences. The planting and harvesting dates are also presented on Table 21.

Table 21: Cropping patterns for the proposed project at Amtu command

Crop	**Coverage (%)**	**Area (ha)**	**Planting date**	**Harvesting date**
Wet Season	**100**	**100**		
Wheat	60	60	15 Jul	11 Dec
Faba bean	20	20	15 Jun	27 Sep
Barely	20	20	15Jun	02 Sep
Dry Season				
Onion	30	30	15Dec	03May
Carrot	20	20	15Dec	13 Apr
Garlic	15	30	15Dec	03May
Fenugreek	15	15	01 Oct	15Mar
Lentil	20	20	01 Oct	15 Mar

4.3 Crop Water Requirement (CWR)

The calculation of crop water requirement is a very important aspect for planning of any irrigation project. Several methods and procedures are available for this. The Food and Agriculture Organization (FAO) of the United Nations has also made available several publications on this subject and other issues related with this. The computer program available in FAO Irrigation and Drainage Paper No. 56 “CROPWAT” has been used for the calculation of Crop Water requirement. This program is based on Penman-Monteith approach and procedures for calculation of crop water requirements and irrigation requirements are mainly based on methodologies presented in FAO Irrigation and Drainage Paper No. 24 “Crop Water Requirements” and No. 33 “Yield Response to Water”.

As recommended in FAO Publications three steps (procedures) are involved in the calculation of the crop water requirement.

4.3.1 Calculation of Reference Evapotranspiration (ETo)

The Reference Evapotranspiration (ETo) represents the potential evaporation of a well-watered grass crop. The water needs of other crops are directly linked to this climatic parameter. Although several methods exist to determine ETo, the Modified Penman-Monteith Method has been recommended as the appropriate combination method to determine ETo from climatic data, on a monthly basis, on: temperature, humidity, sunshine, and wind speed.

4.3.1.1 Climate Data Collection

The methods of calculating evapotranspiration from meteorological data require various climatological and physical parameters. The meteorological factors determining evapotranspiration are weather parameters which provide energy for vaporization and removal of water vapour from the evaporating surface. The evapotranspiration process is determined by the amount of energy available to vaporize water. Solar radiation is the largest energy source and is able to change large quantities of liquid water into water vapour. The principal weather parameters are: rainfall, temperature, relative humidity, wind speed, and sunshine hour.

For the project, the FAO CROPWAT version 8.0 is used to estimate the evapotranspiration by using data obtained from , Asagrt meteorological station (rainfall, minimum and maximum temperature, RH, WR and SS). The monthly ETo for the reference crop has presented in Annex 1.

4.3.1.2 Climate Data Conversion

Climate data are, commonly, standardized by the National Meteorological Service Agencies. However, some conversions are required in order to adjust the data into the format accepted by CROPWAT 8.0 software, i.e. conversion of all the climatic data to the units required for CROPWAT 8.0. Particular attention should be given to the units in which the climatic records are given.

4.3.2 Selection of Values for Crop Coefficient (Kc)

The effect of crop on its water requirement is represented by crop coefficient (Kc). This is presented by the relationship between reference Evapotranspiration (ETo) and crop evapotranspiration ETC as ETc = Kc × ETo. The values for crop coefficient vary with the crop, its stage of growth, growing season and prevailing water condition. Hence, the second step is required to select suitable values for crop coefficient. Based on the recommendation of FAO Irrigation and Drainage Paper No. 56 and No. 33 Yield Response to Water, crop coefficients (Kc values) and other factor or aspects have been used for the selected crops in the calculation as presented in Annex 3.

4.3.3 Effect of Agricultural Practice and Local Conditions

This requires evaluating the effect of climate and its variability over time and area. This also requires to evaluate the effect of soil water availability and agricultural and irrigation practices.

4.3.3.1 Effective Rainfall (Peff)

The proportion of rainfall that can enter and support plant evapotranspiration is said to be effective rainfall (Peff). Of the various methods used for CWR calculation, the USDA soil conservation service method has been used to estimate the effective rainfall for this project, that is:

- Peff = (P* (125 - 0.2 * 3 * P))/125 ………………for P ≤ 250/3 mm
- Peff = 125/3 + 0.1 * P ……………………………for P ≤ 250/3 mm

Where, Peff = Effective rainfall,

P = Total rainfall

As the rainfall amount in the project area is somewhat good the effective rainfall has been accounted for the present irrigation scheme crop water requirement's calculation (See Annex 2). And hence, Asagrt meteorological station rainfall data was directly used to calculate Irrigation Water Requirements (IWR) for Amtu Intak irrigation scheme. Asagrt station rainfall data was used for the dependable rainfall computation.

4.3.3.2 Irrigation Efficiency

To complete the evaluation of the demand, the efficiency of the water distribution system and of application must be known.

The gross requirement of water for irrigation system is very much dependent on the overall efficiency of the irrigation system, which in turn is dependent on several factors: Method of irrigation, type of canal (Lined and/or Unlined), method of operations (simultaneously and continuous or rotational water supply), and availability of structures (for controlling and distribution and measuring and monitoring).

On the basis of these factors, the project has planned to impose surface irrigation method (using furrows). The canal system is lined . Hence, the conveyance efficiency has estimated to be 95% and field application efficiency 60%. As a result of these the overall irrigation efficiency has estimated to be about 52%. According to the soil Lab result, soils of the command area are predominantly characterized as clay textured soil.

The three steps as enumerated above will be able to give the crop water requirement during its cropping period. The losses in the irrigation system have to be incorporated to arrive at the water requirement at the head of the irrigation system.

4.3.4 Crop Water Requirements Calculated for the Project

The crop water requirement for Amtu command has calculated and presented in the annexes for wet season as supplementary irrigation and dry season as full irrigation system. In general, the NIWR for the proposed crops are presented in Annex 5 (5.1- 5.9).

4.3.4.1 Irrigation Duty

Irrigation duty is the volume of water required per hectare for the full flange of the crops. Moreover, it helps in designing an efficient irrigation canal system. The area, which will be irrigated, can be calculated by knowing the total available water at the source and the overall duty for all crops required to be irrigated in different seasons of the years.

The proposed cropping pattern of Amtu Intak irrigation project has showed maximum net irrigation water requirement (NIWR) for overall proposed crops is in the month of March with the amount of mm/day for 17 working or irrigation hours.

For Amtu Intak Irrigation Project, it has estimated to adopt 65% field application efficiency (ea) and 95% conveyance efficiency (ec) as the soil is dominantly Clay textured soils and the canal systems are estimated to be lined . Once the conveyance and field application efficiencies are determined or estimated, the scheme irrigation efficiency (e) for the selected surface irrigation method can be calculated using the following formula:

$$e = \frac{ec * ea * ed}{100} = 65/100*95/100*85/100 = 52\%.$$

Where, e = scheme irrigation efficiency (%)

ec = conveyance efficiency (%)

ea = field application efficiency (%)

ed=distribution efficiency(%)

For the designing of the project, the GIWR is given as follows:

$$GIWR = NIWR/e = 4.49/0.52 = 8.554 \text{ [mm/day] for full irrigation}$$

The GIWR (8.55 mm/day) represents the daily quantity of water that is required to be applied. This water quantity is also used for the determination of the canal discharge in consideration of the time of flow and is defined as the duty, expressed as l/s/ha.

The duty is calculated by:

$$\text{Duty (D)} = \text{GIWR} \times 1000 \times 10 / (t \times 60 \times 60)$$

Where; Duty – the duty [l/s/ha]

GIWR – Gross Irrigation Requirement [mm/day]

t – Daily irrigation or flow hours [hrs]

The duty for the GIWR of 8.55 mm/day and 17 hours of daily irrigation time (t = 17), is supported to be used with furrow irrigation method. Hence, Duty for 17 working hours, as the site is nearer to farmers' village and local farmers have experiences in irrigation, is computed as follows:

$$D = (8.55 \times 10 \times 1000) / (17 \times 60*60) = 1.39 \text{ l/s/h (for full irrigation)}$$

4.4 Irrigation Water Management

4.4.1 Irrigation Methods and Systems

Among the different irrigation systems perennial irrigation system will be used for the project area; and the irrigation water will be obtained from Amtu river and by constructing diversion weir structure and convoying the water commonly through earthen canals (PC, SC, and TC) and then leading to field canals; and finally irrigation takes place mostly in furrows.

For this project, among the various irrigation methods, surface irrigation method has selected. Of the surface irrigation methods furrow, border and basin irrigation methods can be used to supply irrigation water to the plants/crops. However, each method has its own advantages and disadvantages. Care should be taken when choosing the method which is best suited to the local circumstances, i.e., depending on slopes, soil types, selected crop types, amount of water available, etc. of the command area.

Based on the above factors surface irrigation method has proposed for the proposed crops in this project. The method allows applying light irrigation and can be laid out in sloping fields along the contour. Furrow irrigation method is best suited for most of the proposed and row planted crops. In general, furrow irrigation method is simple, manageable and widely practiced irrigation method. This method is suitable for row crops that cannot stand in water for long periods. The only thing required to use this method is row planting of crops. Besides, basin and border irrigation method would be used for the non-row planted crops. Rotational flow water distribution is also recommended for the project area.

4.4.2 Irrigation Schedule (IS)

Irrigation scheduling is one of the managerial activities that aim at effective and efficient utilization of water. IS is expressed in terms of frequency rate and duration of how water is delivered to a farm unit. The number and timing of irrigation vary widely for different crops. It is the function of crops, soil and climate. In this project study it has tried to determine the irrigation intervals of the proposed crops for both wet and dry seasons. The 17 hours irrigation schedules (irrigation depth, intervals, etc) for the proposed crops are presented in Annex 6 (6.1- 6.9) for clay texture soil.

4.4.3 Depth of Irrigation Application

The supply requirements at the field level are determined by the depth and interval of irrigation. These data can be obtained from the soil water balance and are primarily determined by:

- The total available soil water (Sa) in mm/m
- The fraction of available soil water permitting unrestricted evapotranspiration and/or optimal crop growth , and
- The rooting depth (D).

The following formula is used to determine the irrigation depths of the proposed crops in the irrigation scheme including application losses.

$$d = \frac{(P \times Sa) \times D}{Ea}$$

Where; d = Depth of irrigation application

Sa = Total available soil moisture (water) mm/m soil depth.

P = Fraction of available water

(p.sa) = Readily available soil water (mm/m)

D = Rooting depth (m)

Ea = Application efficiency, fraction.

Although the P and D will vary over the crops growing seasons, the maximum depth of irrigation application at maximum root growth stage for the proposed crops can be calculated using the above formula by taking the command total available soil moisture (Sa) content as 160 mm/m. Field application efficiencies (Ea) has already estimated to be taken as 65% for clay soils. Thus, the maximum depth of irrigation application (d) for the different proposed crops in the command has presented in Table 22.

Table 22: Maximum depth of irrigation application for clay texture soils

Crop	Sa (mm/m)	P	D (m)	Ea (%)	ETC	d = (p*Sa*D)/Ea (mm)	I = $\underline{PxS_axD}$/ETC (days)
Wet Season							
Wheat	160	0.55	1	0.65	3.95	135.3846154	22.27848
Barely	160	0.55	1	0.65	3.6	135.3846154	24.44444
Faba bean	160	0.45	0.7	0.65	3.33	77.53846154	15.13514
Dry Season							
Onion	160	0.3	0.3	0.65	4.49	22.15384615	3.207127
carrot	160	0.35	1	0.65	4.38	86.15384615	12.78539
Lentil	160	0.5	0.6	0.65	4.41	73.84615385	10.88435
Fenugreek	160	0.5	0.6	0.65	4.39	73.84615385	10.93394
Garlic	160	0.3	0.3	0.65	4.29		3.356643

Note: The depth of irrigation was determined for Clay soil (Sa = 60 mm/m).

Critical stages of crops at which moisture stress adversely affects the growth, flowering, seed formation and development, and ultimately the yield. Care has to be taken that crops are adequately irrigated at these stages. Proposed crops critical stages are presented in Table 23.

Table 23: The most critical moisture sensitive crop growth stages for proposed crops

Crop	Growth stages
Wheat	Flowering, panicle initiation, grain formation, tillering
Barely	Flowering, panicle initiation, grain formation, tillering
Faba bean	During flowering and yield formation
Onion	Throughout but particularly during bulb formation and enlargement

Fenugreek	Throughout but particularly during flowering and pod-setting
Lentil	Throughout but particularly during flowering and pod-setting
garlic	Late vegetative stage, bulb enlargement
Carrot	Late vegetative stage, root enlargement

4.5 Organizational Aspects of Irrigation Scheme

Administrative and technical problems, in irrigated agriculture, cause great failure of crop yields and irrigation extension unless they are solved as quickly as possible. Thus, water users association has to be established and should be given due attention by the woreda administrative councils and development sectors in solving both social and technical problems.

The project beneficiaries (farmers), who are organized under the water users association, would have the following advantages: Panicle initiation and Grain filling

- ≡ Problems of local administration will be solved.
- ≡ Damaged irrigation Intake and canal structures could be maintained easily and sooner after close supervisions are made by the members of the association and irrigation water managing bodies of the project.
- ≡ The organization could construct common storage facilities so that they could store their surplus and low costly productions and sells when the price rises up.
- ≡ When the association get the by-Laws can take credits of agricultural inputs, farm tools and equipments for its members.
- ≡ The association controls the whole irrigation structures, irrigation water distribution and management operation and maintenance of the Intake and canals.

Therefore, the woreda agricultural development office and the regional cooperative promotion agency should have to take the lion-share to carry out the organization of the water users association and its structural set up.

4.6 Recommended Practices

Recommendations are described as information to be used by farmers to improve the productivity of their resources (farm-lands, labour, etc); thereby increase the outputs and incomes.

4.6.1 Cropping System

Different cropping systems are being practiced in different regions of the country. However, there are different features of cropping system to be considered. Andrew and Kassam (1977) have put the following important characteristics:

- Availability of water: in rain fed agriculture, crop growth is dependent on the availability and duration of moisture during the cropping season.
- Utilization of space and time: crops can be grown sequentially one after another so that time is used to obtain more production. Crops may be mixed and grown together simultaneously intercropped.
- Yield advantages in crop mixtures: the yield advantage results from better total crop water use efficiency of mixture, nitrogen use efficiency in cereal – legume cropping patterns, utilization of space, weed control and use of total available labour.
- Security factors: The significant feature of multiple cropping is a greater dependability of return compared with sole cropping.

Therefore, crop rotation is being practiced in the project area and also proposed to be used. Crop rotation is one means of maintaining soil fertility as well as to control weeds and other pests; and hence gives better grain yields. In the project area cereal/oil crops with legume/vegetable crops rotation system should be followed in order to maintain the soil fertility and to protect crop pests attack.

4.6.2 Agronomic Practices

To promote the irrigated farming and make economically feasible use of improved agronomic practices are vital. High level of production can be attained after farmers of the project area are adopted improved agronomic practices (Annex 7). Agricultural technologies are too broad and may need specification and modification based on local tangible conditions or test on actual fields. During the project implementation time the following improved agronomic practices should be executed:

Field sanitation and land preparation: Plant residues that harbor insect pests, plant diseases and weed seeds should have to be removed out before land preparation on the project field. Deep tillage is required to improve the aeration and water retention conditions of the soil. It also helps the root of the crops to penetrate easily into the soil to extract moisture and nutrients from the lower layers of the soil.

Frequent ploughing in similar soil depth should be avoided to prevent the formation of plow pan, which hinders the root penetration and permeability.

Ploughing is also necessary to destruct the roots of weedy plants and exposing eggs of crop pests that buried in the soil to heavy sun hit. In heavy clay soils (poorly drained soils), to prevent water logging conditions, crops have to be grown on raised beds; and hence needs making broad bed furrows (BBF) by using the BBM (broad bed maker) farm tool.

Planting method and planting materials: in order to have vigorous growth and obtain optimum yields, recommendations of seeding rates (plant populations), spacing between plants and rows should be followed and adopted for the proposed crops. Planting/sowing has proposed on rows. Standardized and quality planting materials/seeds that are free from insect pest, disease and weed seeds, unbroken seeds and healthy seedling materials should be used. Uses of improved seeds (crop varieties) have paramount importance to ensure increased crop production and productivity.

Fertilizer application: fertilizers are used to increase crop production by adding nutrients to the soil and to restore and to maintain the soil fertility. Furthermore, it is important to use the proper type, placement and application rate at the right time so as to ensure increased crop production and productivity. Apart from supplying essential plant nutrients, organic manures are useful to improve the physical structure of the soil, water holding capacity, drainage, workability, etc. Hence, application of organic fertilizers/manures (compost, farm yard manure, crop residues, green manures, etc) is very important since it improves soils physical, chemical as well as biological conditions (See Annex 8).

Irrigation: during irrigation season sufficient amount of water should be provided to the irrigated crops and also supplement in wet season crops when rain shortage occurs. According to the recommended schedule, consideration has to be taken particularly during the crucial moisture sensitive crop growth stages.

Harvesting: harvesting of grain crops should be executed when the crops attains full physiological maturity and optimum moisture content. Harvesting of vegetable crops depends on the purpose to be used, availability of storage facility and maturity.

Threshing: after harvesting grain crops should be sun-dried, for a certain period (days) in the field, to reduce the moisture content, for threshing. Threshing should be done if possible on threshing canvas or concrete grounds; otherwise on clean, well-compacted and animal dung plastered ground.

Storage: the crop product to be stored should be clean, dry and free from field and/or cross-infestation of insect pests. Furthermore, the storage structures should be clean, aerated, rodent as well as termite proofed. To control storage pests attack different chemicals, botanicals and cultural methods including IPM methods can be used.

4.6.3 Recommended Crop Varieties

As the project area has no experiences in crop production habits or practices, different varieties with basket of options have been recommended to be used in this project implementation (see Table 24).

Table 24 List of improved and recommended crop varieties

Crop types	Improved crop verities
Wet Season	
Wheat	Menze(HAR-3008),Ballo(HAR-3816)
Barely	Basso(4731-7),Meserach (Kulumsa)
Faba bean	Adet-Hana(PGRC 25041-2-2), Holetta,Bekej
Dry Season	
Onion	Red croel, Adama red, Melkasa red, Melkam, Mermiru brown, Mermiru white
Garlic	Bishoftu,Tseday 92(G-493)
Carrot	Chanteny red, Nantes forto, Giganta
Lentil	Teshale,Alemtena
Fenugreek	Hunda -01-(FG-18),Chala -01 (FG-47-01)

4.7 Supporting Services

4.7.1 Agricultural Extension

Strong agricultural extension services, trainings, demonstrations, and experience exchange tours should have to be arranged. Demonstrations on new technologies and improved working practices would have to be carried out to the project beneficiaries on the field of FTC (farmers training center). Providing trainings for farmers on different techniques and crop management practices is essential. Seasonally scheduled trainings should be provided for extension staffs including DAs and concerned woreda experts.

Irrigation development agent, who is qualified in plant sciences/general agriculture and well trained/experienced in irrigated agronomy, has to be assigned in order to deliver irrigation aspect extension service for the beneficiaries of the project.

As regards delivery techniques, the field advisers and the subject matter specialists will utilize a wide array of delivery methods:

- Regular field visits with written recommendations given to producers.
- Demonstration plots.
- Pre- and post-season meetings.
- Slack season training sessions.
- Mass media information through radio programs, local press, and publications in the local language.

The target groups for all these activities will be the individual growers, WUAs and cooperatives in the irrigated project command area.

4.7.2 Research and Demonstration

Extension activity should be in liaison with agricultural research at government institutions and universities. Fields/subjects of research should include crops and livestock as well as cross-cutting disciplines such as soil and water management, soil conservation, water harvesting, plant nutrition, irrigation, crop protection and agro-meteorology.

Suitable researchers, if lacking, can be trained in these areas within the framework of international courses. In this way specialized researchers can work together with project technical leaders and ensure the provision of training and research support.

Research should concentrate on site-specific irrigation and fertilization requirements of major crops that are produced in the project command area. A joint extension-research effort will upgrade the capabilities of technical units, such as plant health clinics, crop-water-soil laboratories and weather stations. This will assist in identification of pests and disease that are associated with intensified cropping patterns and will allow specialists to fine tune recommendations with specific soil, water, crop and weather indicators.

The country as a whole will benefit from the extension-research support system set up under the auspices of the irrigation project. For example, an agricultural services and training centre established under the project will coordinate extension, research, training, demonstrations, and site-specific know-how on irrigated agriculture for all farmers located in the vicinity – even those who are not participating in the project. The centre could serve as a source of information on inputs, marketing, prices and post harvest treatments. In addition the center could accommodate training sessions, events and promote extension methodologies as well for all farmers in the surrounding area.

Issues that need prompt research include:

- ≡ Develop improved crop management practices specifically in irrigated agronomy, integrated pest management practices (IPM) and post harvest technology.
- ≡ Varieties development for irrigated cropping.
- ≡ Demonstration works such as farm verification and adaptive field trial should be carried out to demonstrate for farmers practically.
- ≡ Irrigation method and Irrigation scheduling
- ≡ Inputs utilization rates, etc.

4.7.3 Inputs Supply

Poor performances in inputs supply system contribute a lot for the low input-output subsistence farming system. Thus, fertilizers (DAP, UREA and others) should be made available to growers by cooperatives/unions/WUA and other suppliers established in the region. Prices should be competitive or set by officials to prevent over-pricing by suppliers.

Quality agricultural inputs supply are imperative for successful crop production. These include planting seeds, fertilizers and agro-chemicals mainly for pest control. Proper application rate of inputs is also needed. In this study, the type and amount of inputs that are thought to be required during the project implementation period are recommended. The required types and quantity of inputs needed in a hectare basis has presented on Table 25.

Table 25: Input requirements and planting methods for proposed crops

Crop	DAP (Kg/ha)	Urea (Kg/ha)	Pesticide/Fungicide*		Seeding rate (Kg/ha)	Spacing (b/n rows & plants)
			(l/ha)	(kg/ha)		
Wet Season						
Wheat	100	50	0	0	150	BC & BBF
Barely	100	50	2	0	125	BC & BBF
Faba bean						
Dry Season						
Onion	200	100	2	0	4	40×20×10cm
Garlic	200	150	2	2.4	1200	30×10cm
Carrot	200	0	0	0	2	30 × 5
Fenugreek	0	0	0	0	30	20×5cm or BC
Lentil	100	0	0	0	70	Drill on Ridge

4.7.4 Labor and Draft Power

The labour and oxen power requirement of the proposed crops to be grown in the project area are presented in Table 26.

Table 10: Man-days and oxen-days required for the proposed crops per hectare basis

Crop	Man-days	Oxen days
Wet Season		
Wheat	139	30
Barely	139	60
Faba bean		
Dry Season	160	32
Onion	160	34
Garlic	200	28
Carrot	130	40
Lentil	80	16
Fenugreek	100	32

4.7.5 Credit and Financial Services

Credit supply mechanisms are imperative for sound agricultural development. The project beneficiaries' can get credit services from their water users association. Credit arrangements are common in agricultural communities worldwide. So that government intervention could be in the facilitation of credit and financial services like safety net and other sources, etc. Arrangement and provision of credit facilities to beneficiaries is one step for the successful implementation of the project.

4.8 Crop Protection

Crop protection is one of the essential farming activities used to control crops from damage. In the project area, the following crop protection activities should be executed for an effective and efficient control of problematic crop pests:

≡ Training of farmers, development agents (DA) and woreda, zonal and regional experts on pest assessment and different control measures should be practical.

≡ Design and implement an appropriate credit system on revolving fund basis through WUA on the purchase of pesticides.

≡ Supply the required and the right type of agro-chemicals on time

- Identify valuable traditional pest control inputs on time and promote the use of those practices as part of integrated pest management (IPM) measures.
- Conduct regular crop pests assessment/survey on the farm fields
- Spray the recommended type and rate of chemicals (Table 27).
- Use of disease resistant/tolerant crop varieties and field sanitations.
- Conduct timely hand weeding and/or cultivations.

Table 11: Major crop pests and recommended control measures

Crop Pests	Crops attacked	Cultural control method	Chemicals recommended
Stalk borer	Maize, sorghum	Clean field from stalk residues	Diazinone 10% granule10kg/ha or spray Endosulfun 35% EC 2 l/ha
Aphid	Cabbage, Wheat	Use fermented cow urine	Spray Dimatoate 40% EC 1 l/ha
Cut worm	All seedlings, C.pea	Deep plowing	Kruzer FS 150g/m/ 100kg seed dressing
Termites	All crops	Distracting mounds and remove crop and any residues.	-
Weevils	Cereals & pulses	Clean storages and crop left-over's.	Actelic 2% dust 50 gram/quintal seed dressing
Root rot & wilt	Onion	Field sanitation, use of tolerant verities	-
Head smut	Sorghum	Rouging or hand picking diseased plants & burning	-
Striga	Sorghum	Hand pulling, use resistant var.	-

4.9 Yield Projections

Yield projections are normally required in order to determine the feasibility of irrigation projects. In the successive years of project implementation, the productivity of the proposed crops is expected to be increased to the optimum levels through adoption of improved farming practices, efficient input and water utilizations, etc.

For the estimation of yield build-up, reference was made mainly to the following factors:

- Use of modern inputs (Fertilizers, improved seeds, agro-chemicals, etc.).
- Present average yields obtained by farmers and research institutes.

≡ Use of improved crop management or agronomic practices.

≡ Use of better credit services.

≡ Provision of strong agricultural extension services, etc.

Nonetheless, the yield projections are rough estimates and can be treated with same degrees of flexibility until determined by trials (see Table 28).

Table 12: Yield development of proposed crops (qt/ha) for the improved irrigation scheme

Crop	Present kebele current estimate	Future(with additional management		
Wet Season		Year 1 (80%)	Year 2 (90%)	Year 3 (100%)
Wheat	20	36	38	40
Barely	35	63	66.5	70
Faba bean	21	37.8	39.9	42
Dry Season				
Onion	84	151.2	159.6	168
Garlic	65	117	123.5	130
Carrot	60	108	114	120
Lentil	16	28.8	30.4	32
Fenugreek	12	21.6	22.8	24

[1] Present study estimate of rainfed yields based on surveys, regional data and agronomic assessment
[2] Future yield development rate based on management system (rainfed, supplementary or irrigated)

4.10 Resources Required

For the project, there are human and physical resources required:

➲ The human resources required at the operational stage include (those who are well trained in irrigation water management):

≡ Subject Matter Specialist (SMS) at woreda level

≡ Irrigation agronomist at woreda

≡ Plant protection expert at woreda level

- Certified private herbicide, fungicide and pesticide distributer
- Cooperative promotion expert at woreda and kebele level
- 3 Development Agents (DAs) with different disciplines at kebele level
- Supervisors at kebele level

➲ Physical resources required for the project include:

- Motorbike for kebele irrigation agronomist/supervisor

5. Agribusiness Linkage and Market Access

Agribusiness linkages and market access covers the services involved in moving an agricultural product from the farm to the consumer. Numerous interconnected activities are involved in doing this, such as planning production, growing and harvesting, grading, packing, transport, storage, agro- and food processing, distribution, advertising and selling.
Marketing systems are dynamic; they are competitive and involve continuous change and improvement. Businesses that have lower costs, are more efficient, and can deliver quality products, are those that prosper. Those that have high costs, fail to adapt to changes in market demand and provide poorer quality is often forced out of business. Marketing has to be customer-oriented and has to provide the farmer, transporter, trader, processor, etc. with a profit. This requires those involved in marketing chains to understand buyer requirements, both in terms of product and business conditions.

The farmers in the project area sales their produces in the near town market for local traders. They lack market information, low business and negotiating experience, lack of farmers' organizations like cooperatives which encourage producers to produce adequate quantity and quality and fetch better price for their produces. The farmers couldn't have direct linkage with processers, super markets, government institutions and hence most of the markets have been mobilized by brokers and local traders. Business and marketing support services are not well developed to improve their marketing performances.

To solve the existing gaps, it needs to strengthen farmers' groups and cooperatives, the development of agribusiness linkages and access to financial services. Supports will be provided to improve participation, awareness, knowledge and skill and business linkages of the private business enterprises (such as small farmers, cooperatives/unions, processors, wholesalers, retailers, exporters and relevant public agencies). Focus will be given to Farmers' groups, primary cooperatives, unions, and private sectors (such as traders, agro-processors and exporters) who are involved in the development of agribusiness. Mobilizing, organizing and strengthening of farmers' groups, irrigation users marketing cooperatives and multipurpose cooperatives will be the key activities as they are the main vehicle for application of the principles and practices of irrigation farming as a business

It will be expected to facilitate the establishment of agribusiness linkages among small farmers, relevant private and public stakeholders through market access alliances (MAA). The MAA would be established as voluntary platforms. The main purpose of the MAA will be facilitating emergence of agribusiness linkages between organized farmers and other marketing chain stakeholders and service providers. The MAA will comprises of membership of farmers groups, farmers cooperatives, inputs suppliers, primary processors and aggregators, exporters, etc), and key service providers such as micro finance institutions, rural saving and credit cooperatives, banks, transporters as well as relevant Woreda level public institutions.

Furthermore, private-public dialogue is always crucial in business and market development, particularly regarding policy and intuitional supports. The farmers' cooperatives and private sector have a central role to play in identifying and advocating policy, legal and institutional supports that will help government to take directives. Using market access alliances as a plat form, public and private dialogue will be facilitated to create common understanding and collaboration among private and public stakeholders to promote market and agri-business development. Stakeholders in the various value chains will be assisted to identify policy, legal and institutional constraints and articulating impact on actors and functions of the market and agribusiness, and to develop a strategic intervention plan that prioritizes actions and investments for greatest effect.

There are also government institutions which have potential sources of demand for agricultural food products and improve seed. Therefore, it will be facilitated to link farmers to universities/colleges, hospitals and correction centers which involve in the purchase of food items in a regular manner for their communities members as well as seed enterprises like Amhara and Ethiopian seed enterprises which involve in the contractual agreements with the farmers directly for the multiplication of improved seed. These type of agreements have to be watched carefully for sake of "Win-win" relationship among parties. To smooth the demand and supply, contractual farming system will be promoted with defined quantity and quality of the product and specified price.

Benefit description market access farmers can access markets that were formerly out of reach for them. Increased incomes contract farming promotes production of commodities that are sold for a higher price and may be grown without significant extra effort. Reduction in the risk of price fluctuations binding product prices are normally specified in the contract before production, thereby cushioning both the farmer and the contractor against price fluctuations. Credit and financial intermediation contracting offers opportunities for lending to farmers who would otherwise be ineligible for credit. Timely provision of inputs contracting enables timely delivery of inputs and products to markets, even in areas that have poor road networks. Monitoring and labor incentives contract farming is a more efficient way of managing the productivity of labor since efficiency is directly related to return. Reduction of production risk contract farming allows farmers to significantly reduce their risk in the event of crop failure because losses are shared by the contracting parties. Introduction of higher-value crops through contract farming, farmers can start growing new crops that they would otherwise not produce under conventional farming arrangements. Improved collective bargaining contract farming results in improved awareness of the need for collective efforts for farmers' common good and promotion of group and farmer association development. Household spill-over benefits include improved food security, which results from adoption of improved husbandry methods. Improved access to extension many contracting companies provide extension advice and other technical assistance that would, otherwise, not be available to farmers under normal circumstances.

The overall aim of linking farmers to the market is "To provide market linkage innovations and empower smallholder producers to choose what commodities to produce, what technologies to apply for production, when to produce, for whom to produce and when and at what price to sell". Market linkage innovations will enable smallholder producers to sell their produce or purchase needed inputs on time and at competitive prices. There are several ways of linking small farmers to market. The most important ones include linking through growers' association, cooperatives and contract farming. The market linkage is to be done with domestic traders, retailers, agro-processors, exporters and buyer institutions. Therefore, it needs to first mobilize and organize small farmers in groups, cooperatives, association, etc, then to identify most effective ways of linking them to market.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The study has showed that the command area is suitable for irrigated crop production be it topographically, agro-ecologically and the like. During project implementation phase, high crop yields and income would be obtained through the adoption of double cropping systems, adequate supply and proper utilization of inputs, growing high value and productive crops, provision of trainings particularly at low levels and strong extension services as well as credit accesses, and application of efficient crop protection measures.

Generally, agricultural production will be more confidential as irrigation water supply will be available throughout the year and dependency on rainfall would be minimized. Furthermore, Irrigation development project will also create an employment opportunity of labour in the project area; and thereby food self-sufficiency/security would be assured specifically in the locality.

6.2. Recommendations

The following points are recommended for the success full implementation of this project:

- The project Water Users Association (WUA) should be established.
- Training on irrigation agronomy and management should be provided to DAs and beneficiary framers to equip them with sufficient techniques and skills on irrigation methods, utilization of agricultural inputs (specifically improved seeds), improved crop management practices, water use efficiencies, etc.
- It is quite important to implement the irrigation project in accordance with the proposed cropping pattern and calendar so as to avoid irrigation water management related problems.
- It is also important to strengthen inputs and credits supplying institutions in the area
- As soils of the command area are predominantly heavy clay textured soils, and hence careful water management measures should be taken and optimum moisture content should be maintained to improve workability of the soil during land preparation.
- Different demonstration and adaptation trials should be adopted on farmers' fields.
- Different soil and water conservation and crop protection measures should be strengthened.
- As the irrigation water source is from Amtu river and has limited water resource and planned to irrigate limited area, water should be used as efficiently as possible. Wastage of water should be avoided.

Note: The proposed cropping pattern for Amtu Intak irrigation scheme is based on the existing knowledge of the local farmers, market accesses, environmental adaptability, productivity, etc. conditions. However, the proposed pattern is flexible and can be revised according to the prevailing market demand and changes in production objectives of the farmers.

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ANNEXES

Annex 1: Meteorological and ETo data of the study area

Country: Ethiopia; Station: Yinager
, Asagrt: Alt: 2352 masl, Lat: 9.2^0 (North), Long: 39.4^0 (East)

Month	Min Temp	Max Temp	Humidity	Wind	Sunshine	Radiation	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	8.7	25.3	40	138	8.4	19.9	3.95
February	9.3	25	38	138	8.1	20.7	4.22
March	9.8	26.1	43	130	7.2	20.4	4.27
April	10	25.5	46	138	7.6	21.2	4.4
May	10.5	25	52	130	6.8	19.5	4.07
June	9.6	22.6	65	104	5.3	16.9	3.32
July	10.1	20.1	75	95	2.9	13.5	2.64
August	9.3	20.1	78	86	4.2	15.7	2.84
September	8.8	21.4	70	104	5.4	17.6	3.2
October	7.8	23.1	53	138	8	20.7	3.87
November	7.2	23.6	44	147	9.2	21.2	3.96
December	6.8	24.4	41	138	8.9	20.1	3.76
Average	9	23.5	54	124	6.8	19	3.71

Annex 2: Rainfall data of Ginager Station

Month	Av.Rf	80%Dep	Eff.Rf
Jan.	46.1	38.3	36.9
Feb.	40.2	33.4	32.1
Mar.	161.4	134.0	129.1
Apr	154.0	127.9	123.2
May	84.5	70.2	67.6
Jun	108.2	89.8	86.5
Jul	361.9	300.5	289.5
Aug	435.6	361.8	348.5
Sep	193.4	160.6	154.7
Oct	101.1	84.0	80.9
Nov	86.7	72.0	69.4
Dec	33.2	27.5	26.5

Annex 3: Length of growing period (LGP), crop coefficient (Kc) and others data for irrigated crops in wet and dry seasons

Crops proposed	LGP	Initial	Dev.	Mid	Late	Planting Date	Harvest date	Land share %	Yield response					Critical depletion (P)			Root depth (m) (stages)		crop max.ht (m)
Wet Season								**100**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**Initial**	**Late**	
Wheat	135	15	25	60	35	01 Aug	27-Nov	33	0.20	0.65	0.55	0.20	1.15	0.50	0.55	0.55	0.20	1.00	1.0
	Kc	0.3		1.15	0.4														
Barely	135	15	25	60	35	15 jun	02-Oct	67	0.20	0.65	0.55	0.20	1.15	0.50	0.55	0.55	0.20	1.00	1.0
	Kc	0.3		1.15	0.25														
Faba bean	150	20	30	60	40	01-Jul	27-Oct	5	0.20	1.10	0.75	0.20	1.15	0.40	0.45	0.45	0.25	0.50	0.8
	Kc	0.5		1.15	0.3														
Dry Season								**100**											
Garlic	140	15	25	65	35	01-Dec	20-Mar	48	0.20	1.10	0.75	0.20	1.15	0.25	0.30	0.30	0.15	0.30	0.3
	Kc	0.7		1.0	0.7														
Carrot	120	20	30	50	20	01 Dec	30 Mar	14	0.20	0.80	0.60	0.20	0.70	0.30	0.35	0.35	0.15	0.50	0.3
	Kc	0.7		1.05	0.95														
Onion	130	10	25	60	35	01-Dec	20 Mar	26	0.45	0.60	0.80	0.30	1.10	0.25	0.30	0.30	0.15	0.30	0.4
	Kc	0.7		1.05	0.75														
Fenugreek	150	20	30	60	40	01-Dec	15-Mar	13	0.20	0.80	0.85	0.30	0.85	0.45	0.50	0.50	0.25	0.60	0.5
	Kc	0.4		1.10	0.3														
Lentil (dry)	135	20	25	55	35	01-Dec	15-Mar	13	0.20	0.80	0.85	0.25	0.85	0.45	0.50	0.50	0.20	0.60	0.5
	Kc	0.4		1.10	0.3														
G. Total								**200**											

- ***Wet season crops***

Annex 5.1: Net Crop Water Requirements of Wheat

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jul	2	Init	0.7	1.85	11.1	32.9	0
Jul	3	Init	0.7	1.9	20.9	54.3	0
Aug	1	Deve	0.7	1.95	19.5	54.2	0
Aug	2	Deve	0.76	2.15	21.5	55.6	0
Aug	3	Deve	0.84	2.48	27.3	50	0
Sep	1	Deve	0.92	2.82	28.2	43.7	0
Sep	2	Mid	0.99	3.16	31.6	38.9	0
Sep	3	Mid	1	3.44	34.4	33.8	0.6
Oct	1	Mid	1	3.67	36.7	27.4	9.2
Oct	2	Mid	1	3.89	38.9	21.7	17.2
Oct	3	Mid	1	3.92	43.1	21.3	21.8
Nov	1	Mid	1	3.95	39.5	22.4	17.1
Nov	2	Late	0.9	3.56	35.6	21.8	13.8
Nov	3	Late	0.66	2.59	25.9	17.4	8.5
Dec	1	Late	0.43	1.64	16.4	11.1	5.4
Dec	2	Late	0.3	1.13	1.1	0.6	1.1
					431.7	506.9	94.8

Annex 5.2: Net Crop Water Requirement of Barely

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jun	3	Init	0.3	0.93	0.9	3.2	0.9
Jul	1	Init	0.3	0.86	8.6	44.8	0
Jul	2	Deve	0.3	0.8	8	54.8	0
Jul	3	Deve	0.47	1.26	13.9	54.3	0
Aug	1	Deve	0.71	1.98	19.8	54.2	0
Aug	2	Deve	0.95	2.69	26.9	55.6	0
Aug	3	Mid	1.12	3.31	36.4	50	0
Sep	1	Mid	1.13	3.47	34.7	43.7	0
Sep	2	Mid	1.13	3.6	36	38.9	0
Sep	3	Mid	1.13	3.85	38.5	33.8	4.8
Oct	1	Late	0.92	3.34	33.4	27.4	6
Oct	2	Late	0.43	1.65	11.5	15.2	0

						268.7	475.7	11.7

Annex 5.3 Net Crop Water Requirement of Faba bean

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jun	2	Init	0.4	1.33	1.3	2.2	1.3
Jun	3	Init	0.4	1.24	12.4	31.6	0
Jul	1	Init	0.4	1.15	11.5	44.8	0
Jul	2	Deve	0.43	1.15	11.5	54.8	0
Jul	3	Deve	0.6	1.62	17.8	54.3	0
Aug	1	Deve	0.77	2.13	21.3	54.2	0
Aug	2	Mid	0.93	2.64	26.4	55.6	0
Aug	3	Mid	0.97	2.88	31.7	50	0
Sep	1	Mid	0.97	3	30	43.7	0
Sep	2	Mid	0.97	3.11	31.1	38.9	0
Sep	3	Mid	0.97	3.33	33.3	33.8	0
Oct	1	Late	0.9	3.28	32.8	27.4	5.4
Oct	2	Late	0.69	2.68	26.8	21.7	5.1
Oct	3	Late	0.47	1.85	20.4	21.3	0
Nov	1	Late	0.35	1.38	1.4	2.2	1.4
					309.7	536.5	13.2

- ***Dry season crops***

Annex 5.5: Net Crop Water Requirement of Onion

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Dec	1	Init	0.7	2.68	26.8	13.6	13.2
Dec	2	Init	0.7	2.64	26.4	7.9	18.4
Dec	3	Deve	0.71	2.73	30	10	19.9
Jan	1	Deve	0.78	3.01	30.1	13.5	16.6
Jan	2	Deve	0.84	3.32	33.2	15	18.2
Jan	3	Deve	0.91	3.67	40.4	14.2	26.2
Feb	1	Deve	0.98	4.04	40.4	10.4	30
Feb	2	Mid	1.04	4.39	43.9	8.4	35.5
Feb	3	Mid	1.06	4.49	35.9	18.9	17
Mar	1	Mid	1.06	4.5	45	33.5	11.5
Mar	2	Late	1.04	4.45	44.5	44	0.6
Mar	3	Late	0.95	4.09	45	42.2	2.8
Apr	1	Late	0.84	3.67	36.7	40.3	0

Apr	2	Late	0.77	3.4	13.6	16.2	0

Annex 5.6: Net Crop Water Requirement of Garlic

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Dec	1	Init	0.7	2.68	26.8	11.1	15.7
Dec	2	Deve	0.72	2.71	27.1	6.3	20.7
Dec	3	Deve	0.84	3.2	35.2	8.1	27.1
Jan	1	Mid	0.96	3.75	37.5	10.9	26.6
Jan	2	Mid	1.01	3.98	39.8	12.2	27.7
Jan	3	Mid	1.01	4.08	44.8	11.5	33.3
Feb	1	Mid	1.01	4.17	41.7	8.2	33.5
Feb	2	Mid	1.01	4.26	42.6	6.6	36.1
Feb	3	Mid	1.01	4.28	34.2	15.7	18.5
Mar	1	Mid	1.01	4.29	42.9	28.5	14.4
Mar	2	Late	1	4.25	42.5	37.7	4.8
Mar	3	Late	0.91	3.94	43.4	36.1	7.3
Apr	1	Late	0.82	3.59	35.9	34.5	1.4
Apr	2	Late	0.74	3.27	29.4	31.2	0

Annex 5.7 Net Crop Water Requirement of Carrot

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Nov	1	Init	0.7	2.75	27.5	22.4	5.2
Nov	2	Init	0.7	2.77	27.7	21.8	5.9
Nov	3	Deve	0.77	2.99	29.9	17.4	12.5
Dec	1	Deve	0.89	3.4	34	11.1	22.9
Dec	2	Deve	1.01	3.8	38	6.3	31.6
Dec	3	Mid	1.06	4.07	44.7	8.1	36.6
Jan	1	Mid	1.06	4.13	41.3	10.9	30.4
Jan	2	Mid	1.06	4.19	41.9	12.2	29.8
Jan	3	Mid	1.06	4.29	47.2	11.5	35.7
Feb	1	Late	1.06	4.38	43.8	8.2	35.6
Feb	2	Late	1.02	4.32	43.2	6.6	36.6
Feb	3	Late	0.98	4.14	33.1	15.8	17.3
					452.3	152.2	300.2

Annex 5.7 Net Crop Water Requirement of Lentil

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Nov	1	Init	0.4	1.57	15.7	22.4	0
Nov	2	Init	0.4	1.58	15.8	21.8	0
Nov	3	Deve	0.56	2.17	21.7	17.4	4.4
Dec	1	Deve	0.84	3.23	32.3	11.1	21.3
Dec	2	Mid	1.09	4.09	40.9	6.3	34.6
Dec	3	Mid	1.12	4.27	47	8.1	38.9
Jan	1	Mid	1.12	4.34	43.4	10.9	32.4
Jan	2	Mid	1.12	4.41	44.1	12.2	31.9
Jan	3	Mid	1.12	4.51	49.6	11.5	38.1
Feb	1	Late	1.11	4.58	45.8	8.2	37.6
Feb	2	Late	0.94	3.97	39.7	6.6	33.2
Feb	3	Late	0.73	3.1	24.8	15.7	9
Mar	1	Late	0.52	2.22	22.2	28.5	0
Mar	2	Late	0.35	1.48	7.4	18.8	0
					450.4	199.5	281.4

Annex 5.7 Net Crop Water Requirement of Fenugreek

			coeff	mm/day	mm/dec	mm/dec	mm/dec
Nov	1	Init	0.4	1.57	15.7	22.4	0
Nov	2	Init	0.4	1.58	15.8	21.8	0
Nov	3	Deve	0.5	1.94	19.4	17.4	2
Dec	1	Deve	0.68	2.59	25.9	11.1	14.8
Dec	2	Deve	0.85	3.22	32.2	6.3	25.9
Dec	3	Mid	1.04	3.98	43.8	8.1	35.7
Jan	1	Mid	1.11	4.32	43.2	10.9	32.3
Jan	2	Mid	1.11	4.39	43.9	12.2	31.7
Jan	3	Mid	1.11	4.49	49.4	11.5	37.9
Feb	1	Mid	1.11	4.59	45.9	8.2	37.7
Feb	2	Late	1.1	4.66	46.6	6.6	40
Feb	3	Late	0.9	3.82	30.5	15.7	14.8
Mar	1	Late	0.61	2.59	25.9	28.5	0
Mar	2	Late	0.37	1.56	7.8	18.8	0
					446.1	199.5	272.9

Annex 4: Irrigation schedule of Amtu Intak Irrigation Project for proposed crops

- ***Wet season crops***

- *Annex 6.1 Irrigation Schedule of Wheat*

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
15-Jul	1	Init	0	1	100	60	10.9	0	0	15.5	1.79
21-Jul	7	Init	0	1	100	52	9.3	0	0	13.3	0.26
31-Jul	17	Init	0	1	100	53	9.5	0	0	13.5	0.16
11-Aug	28	Dev	0	1	100	55	9.9	0	0	14.2	0.15
21-Aug	38	Dev	0	1	100	62	11.1	0	0	15.8	0.18
26-Aug	43	Dev	0	1	100	55	9.9	0	0	14.2	0.33
30-Aug	47	Dev	0	1	100	55	9.9	0	0	14.2	0.41
6-Sep	54	Dev	0	1	100	63	11.3	0	0	16.1	0.27
10-Sep	58	Dev	0	1	100	63	11.3	0	0	16.1	0.47
16-Sep	64	Dev	0	1	100	70	12.6	0	0	18.1	0.35
20-Sep	68	Mid	0	1	100	70	12.6	0	0	18.1	0.52
25-Sep	73	Mid	0	1	100	57	10.3	0	0	14.7	0.34
29-Sep	77	Mid	0	1	100	57	10.3	0	0	14.7	0.43
2-Oct	80	Mid	0	1	100	60	10.8	0	0	15.4	0.59
5-Oct	83	Mid	0	1	100	61	11	0	0	15.7	0.61
9-Oct	87	Mid	0	1	100	61	11	0	0	15.7	0.45
12-Oct	90	Mid	0	1	100	64	11.4	0	0	16.4	0.63
15-Oct	93	Mid	0	1	100	65	11.7	0	0	16.7	0.64
19-Oct	97	Mid	0	1	100	65	11.7	0	0	16.7	0.48
22-Oct	100	Mid	0	1	100	65	11.7	0	0	16.8	0.65
25-Oct	103	Mid	0	1	100	65	11.8	0	0	16.8	0.65
29-Oct	107	Mid	0	1	100	65	11.8	0	0	16.8	0.49

1-Nov	110	Mid	0	1	100	66	11.8	0	0	16.8	0.65
5-Nov	114	Mid	0	1	100	66	11.9	0	0	16.9	0.49
9-Nov	118	Mid	0	1	100	66	11.9	0	0	16.9	0.49
12-Nov	121	End	0	1	100	62	11.1	0	0	15.8	0.61
15-Nov	124	End	0	1	100	59	10.7	0	0	15.3	0.59
19-Nov	128	End	0	1	100	59	10.7	0	0	15.3	0.44
26-Nov	135	End	0	1	100	57	10.3	0	0	14.8	0.24
30-Nov	139	End	0	1	100	57	10.3	0	0	14.8	0.43
11-Dec	End	End	0	1	0	40					

Annex 6.2: Irrigation Schedule of Barely

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow	
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha	
15-Jun	1	Init	0	1	100	63	11.3	0	0	16.2	1.87	
20-Jun	6	Init	0	1	100	52	9.3	0	0	13.3	0.31	
1-Jul	17	Init	0	1	100	59	10.7	0	0	15.3	0.16	
11-Jul	27	Dev	0	1	100	56	10	0	0	14.3	0.17	
21-Jul	37	Dev	0	1	100	56	10.1	0	0	14.4	0.17	
31-Jul	47	Dev	0	1	100	62	11.1	0	0	15.9	0.18	
6-Aug	53	Dev	0	1	100	55	9.9	0	0	14.2	0.27	
10-Aug	57	Dev	0	1	100	55	9.9	0	0	14.2	0.41	
16-Aug	63	Dev	0	1	100	61	10.9	0	0	15.6	0.3	
20-Aug	67	Mid	0	1	100	61	10.9	0	0	15.6	0.45	
26-Aug	73	Mid	0	1	100	64	11.6	0	0	16.6	0.32	
30-Aug	77	Mid	0	1	100	64	11.6	0	0	16.6	0.48	
6-Sep	84	Mid	0	1	100	67	12.1	0	0	17.2	0.29	
10-Sep	88	Mid	0	1	100	67	12.1	0	0	17.2	0.5	
16-Sep	94	Mid	0	1	100	70	12.5	0	0	17.9	0.35	

20-Sep	98	Mid	0	1	100	70	12.5	0	0	17.9	0.52	
25-Sep	103	Mid	0	1	100	56	10.1	0	0	14.4	0.33	
29-Sep	107	Mid	0	1	100	56	10.1	0	0	14.4	0.42	
2-Oct	110	Mid	0	1	100	58	10.5	0	0	15	0.58	
5-Oct	113	Mid	0	1	100	60	10.7	0	0	15.3	0.59	
9-Oct	117	Mid	0	1	100	60	10.7	0	0	15.3	0.44	
12-Oct	120	Mid	0	1	100	59	10.5	0	0	15.1	0.58	
15-Oct	123	End	0	1	100	58	10.4	0	0	14.9	0.58	
19-Oct	127	End	0	1	100	58	10.4	0	0	14.9	0.43	
26-Oct	134	End	0	1	100	57	10.3	0	0	14.8	0.24	
30-Oct	138	End	0	1	100	57	10.3	0	0	14.8	0.43	
11-Nov	End	End	0	1	0	37						

Annex 6.3 Irrigation Schedule of Faba bean

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
15-Jun	1	Init	0	0.91	91	56	11	0	0	15.7	1.81
27-Oct	End	End	11.9	1	100	0					

- ***Dry season crops***

Annex 6.4 Irrigation Schedule of Onion

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
1-Dec	1	Init	0	0.71	71	60	11.1	0	0	15.9	1.84
5-Dec	5	Init	0	1	100	43	8.6	0	0	12.3	0.36
9-Dec	9	Init	0	1	100	38	8.5	0	0	12.1	0.35
12-Dec	12	Init	0	1	100	36	8.4	0	0	12	0.46
15-Dec	15	Init	0	1	100	33	8.2	0	0	11.7	0.45
19-Dec	19	Init	0	1	100	31	8.2	0	0	11.7	0.34
24-Dec	24	Init	0	1	100	34	9.8	0	0	14	0.33
29-Dec	29	Dev	0	1	100	32	9.9	0	0	14.2	0.33
2-Jan	33	Dev	0	1	100	36	11.8	0	0	16.9	0.49
6-Jan	37	Dev	0	1	100	35	12	0	0	17.2	0.5
10-Jan	41	Dev	0	1	100	33	12	0	0	17.2	0.5
16-Jan	47	Dev	0	1	100	34	13.4	0	0	19.1	0.37
20-Jan	51	Dev	0	1	100	32	13.3	0	0	19	0.55
26-Jan	57	Dev	0	1	100	36	15.9	0	0	22.7	0.44
30-Jan	61	Dev	0	1	100	32	14.7	0	0	21	0.61
4-Feb	66	Dev	0	1	100	33	15.8	0	0	22.6	0.52
9-Feb	71	Dev	0	1	100	32	16.2	0	0	23.1	0.53
14-Feb	76	Dev	0	1	100	36	18.7	0	0	26.7	0.62
19-Feb	81	Mid	0	1	100	35	19	0	0	27.2	0.63
25-Feb	87	Mid	0	1	100	33	17.7	0	0	25.3	0.49
2-Mar	92	Mid	0	1	100	33	18	0	0	25.7	0.59
6-Mar	96	Mid	0	1	100	33	18	0	0	25.7	0.74
10-Mar	100	Mid	0	1	100	33	18	0	0	25.7	0.74
16-Mar	106	End	0	1	100	33	17.8	0	0	25.4	0.49

20-Mar	110	End	0	1	100	33	17.8	0	0	25.4	0.74
26-Mar	116	End	0	1	100	30	16.4	0	0	23.4	0.45
30-Mar	120	End	0	1	100	30	16.4	0	0	23.4	0.68
11-Apr	132	End	0	1	100	34	18.1	0	0	25.9	0.25
14-Apr	End	End	11.9	1	100	6					

Annex 6.5Irrigation Schedule of Garlic

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
1-Dec	1	Init	0	0.66	66	54	28.8	0	0	41.1	4.76
9-Dec	9	Init	0	1	100	27	12.8	0	0	18.3	0.26
15-Dec	15	Init	0	1	100	30	13	0	0	18.6	0.36
20-Dec	20	Dev	0	1	100	27	10.8	0	0	15.5	0.36
25-Dec	25	Dev	0	1	100	32	11.8	0	0	16.9	0.39
29-Dec	29	Dev	0	1	100	28	9.6	0	0	13.7	0.4
1-Jan	32	Dev	0	1	100	31	10.1	0	0	14.5	0.56
5-Jan	36	Dev	0	1	100	38	11.3	0	0	16.1	0.47
9-Jan	40	Dev	0	1	100	42	11.3	0	0	16.1	0.47
12-Jan	43	Mid	0	1	100	43	11.7	0	0	16.7	0.65
15-Jan	46	Mid	0	1	100	44	12	0	0	17.1	0.66
19-Jan	50	Mid	0	1	100	44	12	0	0	17.1	0.49
22-Jan	53	Mid	0	1	100	45	12.1	0	0	17.3	0.67
24-Jan	55	Mid	0	1	100	30	8.2	0	0	11.6	0.67
26-Jan	57	Mid	0	1	100	30	8.2	0	0	11.6	0.67
28-Jan	59	Mid	0	1	100	30	8.2	0	0	11.6	0.67
30-Jan	61	Mid	0	1	100	30	8.2	0	0	11.6	0.67
1-Feb	63	Mid	0	1	100	31	8.2	0	0	11.8	0.68
4-Feb	66	Mid	0	1	100	31	8.5	0	0	12.1	0.47
6-Feb	68	Mid	0	1	100	31	8.3	0	0	11.9	0.69

8-Feb	70	Mid	0	1	100	31	8.3	0	0	11.9	0.69
10-Feb	72	Mid	0	1	100	31	8.3	0	0	11.9	0.69
12-Feb	74	Mid	0	1	100	32	8.5	0	0	12.2	0.7
14-Feb	76	Mid	0	1	100	32	8.5	0	0	12.2	0.7
16-Feb	78	Mid	0	1	100	32	8.5	0	0	12.2	0.7
18-Feb	80	Mid	0	1	100	32	8.5	0	0	12.2	0.7
20-Feb	82	Mid	0	1	100	32	8.5	0	0	12.2	0.7
22-Feb	84	Mid	0	1	100	32	8.6	0	0	12.2	0.71
24-Feb	86	Mid	0	1	100	32	8.6	0	0	12.2	0.71
26-Feb	88	Mid	0	1	100	32	8.6	0	0	12.2	0.71
28-Feb	90	Mid	0	1	100	32	8.6	0	0	12.2	0.71
2-Mar	92	Mid	0	1	100	32	8.6	0	0	12.3	0.71
4-Mar	94	Mid	0	1	100	32	8.6	0	0	12.3	0.71
6-Mar	96	Mid	0	1	100	32	8.6	0	0	12.3	0.71
8-Mar	98	Mid	0	1	100	32	8.6	0	0	12.3	0.71
10-Mar	100	Mid	0	1	100	32	8.6	0	0	12.3	0.71
12-Mar	102	Mid	0	1	100	31	8.5	0	0	12.1	0.7
14-Mar	104	Mid	0	1	100	31	8.5	0	0	12.1	0.7
16-Mar	106	End	0	1	100	31	8.5	0	0	12.1	0.7
18-Mar	108	End	0	1	100	31	8.5	0	0	12.1	0.7
20-Mar	110	End	0	1	100	31	8.5	0	0	12.1	0.7
25-Mar	115	End	0	1	100	44	11.8	0	0	16.9	0.39
29-Mar	119	End	0	1	100	44	11.8	0	0	16.9	0.49
1-Apr	122	End	0	1	100	43	11.5	0	0	16.4	0.63
5-Apr	126	End	0	1	100	40	10.8	0	0	15.4	0.45
9-Apr	130	End	0	1	100	40	10.8	0	0	15.4	0.45
12-Apr	133	End	0	1	100	37	10.1	0	0	14.5	0.56
15-Apr	136	End	0	1	100	36	9.8	0	0	14	0.54
19-Apr	End	End	0	1	100	24					

Annex 6.7: Irrigation Schedule of Carrot

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
1-Nov	1	Init	0	0.71	71	57	16.1	0	0	23	2.66
6-Nov	6	Init	0	1	100	37	12.8	0	0	18.3	0.42
11-Nov	11	Init	0	1	100	36	14.5	0	0	20.8	0.48
22-Nov	22	Dev	0	1	100	31	17.1	0	0	24.4	0.26
5-Dec	35	Dev	0	1	100	36	25.2	0	0	36.1	0.32
15-Dec	45	Dev	0	1	100	35	29.4	0	0	42	0.49
25-Dec	55	Mid	0	1	100	36	32	0	0	45.7	0.53
5-Jan	66	Mid	0	1	100	39	35.2	0	0	50.2	0.53
16-Jan	77	Mid	0	1	100	39	35.2	0	0	50.3	0.53
25-Jan	86	Mid	0	1	100	36	32.1	0	0	45.9	0.59
4-Feb	96	Mid	0	1	100	39	35	0	0	50	0.58
13-Feb	105	End	2.9	1	100	36	32.3	0	0	46.1	0.59
22-Feb	114	End	0	1	100	40	35.6	0	0	50.8	0.65
28-Feb	End	End	0	1	100	13					

Annex 6.7 Irrigation Schedule of Lentil

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow	
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha	
1-Nov	1	Init	0	0.9	90	52	46.4	0	0	66.3	7.67	
8-Dec	38	Dev	0	1	100	51	22.6	0	0	32.4	0.1	
14-Dec	44	Dev	0	1	100	53	19.7	0	0	28.1	0.54	
20-Dec	50	Mid	0	1	100	59	21.4	0	0	30.6	0.59	
26-Dec	56	Mid	0	1	100	60	21.5	0	0	30.7	0.59	
31-Dec	61	Mid	0	1	100	59	21.3	0	0	30.5	0.71	

6-Jan	67	Mid	0	1	100	56	20.2	0	0	28.9	0.56	
11-Jan	72	Mid	0	1	100	60	21.8	0	0	31.1	0.72	
18-Jan	79	Mid	0	1	100	55	19.9	0	0	28.5	0.47	
24-Jan	85	Mid	0	1	100	58	20.7	0	0	29.6	0.57	
30-Jan	91	Mid	0	1	100	58	20.9	0	0	29.9	0.58	
4-Feb	96	Mid	0	1	100	52	18.8	0	0	26.9	0.62	
9-Feb	101	End	0	1	100	52	18.9	0	0	27	0.62	
15-Feb	107	End	0	1	100	60	21.5	0	0	30.7	0.59	
21-Feb	113	End	0	1	100	56	20	0	0	28.6	0.55	
15-Mar	End	End	0	1	100	8						

Annex 6.7: Irrigation Schedule of Fenugreek

Date	Day	Stage	Rain	Ks	ETa	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
1-Nov	1	Init	0	0.91	91	53	24.5	0	0	34.9	4.04
20-Dec	50	Dev	0	1	100	51	49.9	0	0	71.4	0.17
6-Jan	67	Mid	0	1	100	52	56.5	0	0	80.7	0.55
22-Jan	83	Mid	0	1	100	53	57.2	0	0	81.7	0.59
6-Feb	98	Mid	0	1	100	54	57.9	0	0	82.7	0.64
19-Feb	111	End	0	1	100	50	54.4	0	0	77.7	0.69
15-Mar	End	End	11.9	1	100	3					

Annex 5: Proposed crops and their improved agronomic managements (packages)

Onion

Onion grows well between altitude ranges of 1800-2500m.a.s.l. It can be grown on many soils but well drained loamy or sandy loam soils are preferred. High level of organic matter is required for the optimum growth of the crop. A pH 0f 5.8-6.8 is most favorable.

Field Preparation: Seeds are normally sown in seedbeds and transplanted to prepared fields after about 45-60 days when seedlings are 8-12cm in height. As onions are shallow rooted, meticulous watering and mulching with straw is advisable to minimize evaporation losses and suppress weed growth.

Seed Rate: The seed rate for direct planting may go up to 12-15kg/ha. But, for transplanting, the normal seed rate is between 5-8kg. Recommended spacing is 40cm between rows and 20cm between plants. Onion can also be directly sown to the field and latter thinned to the given spacing.

Fertilizer: For optimum yields, applications of 150-200kg DAP and 100-150kg Urea per hectare is very appropriate.

Weed Control: A minimum of two hand weeding are required.

Disease: Purple blotch, downy mildew and anthracnose are major diseases of onion. Control measures include crop rotation, plant hygiene and removal and burning of onion stubble after harvest.

Insect Pests: Onion trips are the major insect pests of the crop. Other pests include cut worms, onion fly and armyworm. Endosulfan 35% E.C. at the rate of 1.5lt/ha controls these pests.

Irrigation: Onion requires 350-550mm water during its growth period. It is sensitive to water stress and the crop requires frequent, light irrigation, which are scheduled when about 25% of available water in the first 30cm soil depth has been depleted by the crop. The most common methods used are furrow and basin.

- kg/ha
- Planting depth: 3-5 cm
- Fertilizer application: no recommendations.
- Weeding: needs two weeding:-
    - 1st weeding 25-30 days after sowing
    - 2nd weeding as required (after 50 days from planting).

Faba bean

Ploughing frequency: 3 times (average)

Sowing method: row planting/seed drilling

- Recommended spacing is 40cm b/n rows.

Seed rate: 120kg/ha

Sowing depth: 4-7 cm

Fertilizer application:

- DAP: 100 kg/ha and all apply at time of sowing.

Weeding: needs two hand weeding

- 1st weeding 25-30 days after sowing
- 2nd weeding 55-60 days after sowing
  -
  - Fertilizer application: no recommendations.
  - Weeding: needs two weeding:-
    - 1st weeding 25-30 days after sowing
    - 2nd weeding as required (after 50 days from planting).

Fenugreek

- Ploughing frequency: 3 times
- Sowing method: broad casting or row planting
  - Recommended spacing: 20cm b/n rows and 5cm b/n plants.
- See rate: 30 kg/ha
- Planting depth: 3-5 cm
- Fertilizer application: no recommendations.
- Weeding: needs two weeding:-
  - 1st weeding 25-30 days after sowing

2nd weeding as required (after 50 days from planting

Garlic

Ploughing frequency: 4 times (average)
Sowing method: row planting

- Recommended spacing: 30cm b/n rows and 10 cm b/n plants

Seed rate: 1200 kg/ha
Fertilizer Application:

- 200 kg/ha DAP and all apply at planting time
- 150 kg/ha Urea apply half at time of planting and half 45 days after planting.

Weeding: at least 4 times hoeing and/or hand weeding

Wheat

Ploughing frequency: 4 times (average)
Sowing method: broad casting or row

- Recommended spacing for row planting b/n rows is 20-25 cm

See rate: 175 kg/ha for BC or 125 kg/ha for row planting.
Planting depth: 3-5cm
Fertilizer application:

- DAP 100 kg/ha all at time of sowing
- Urea 100kg/ha (half at time of sowing and half when the plant reach at ankle height

Weeding: needs two weeding

- 1st weeding 20-25 days after sowing
- 2nd weeding 50-60 days after sowing

Barley

Ploughing frequency: 3 times (average)
Sowing method: broad casting or row planting.

- Recommended spacing for row planting b/n rows is 20-25 cm.

See rate: 125 kg/ha for BC or 85kg/ha for row planting.
Planting depth: 3-4 cm
Fertilizer application:

- DAP 100 kg/ha all at time of sowing
- Urea 50 kg/ha (half at time of sowing and half when the plant reach at ankle height

Weeding: needs two weeding

- 1st weeding 25-35 days after sowing
- 2nd weeding 55-60 days after sowing

Annex 6: Methods of compost preparation

Compost can be prepared in two ways:

I. Heap stock or above ground method:

The following are the steps to prepare above ground compost:

a. Site selection: select a site based on the availability if shack and water.
b. Collection of animal manure ash decomposed plant residue and other materials.
c. Put plant as the first layer with 20 cm thickness
d. Apply water
e. Then cover by ash at a rate of one kg/one square meter
f. Add animal manure at a rate of 3kg/one square meter
g. After the manure add 5cm thick soil.
h. Repeat the above steps from d,e,f and g control the highest reaches 1.5m high.
i. Cover the heap with dried grass or anything and cover the sides by soil to protect from wind.
j. Within 3-5 weeks time, every week turn it top down at night or in the early morning; add water if it shows dryness, but not too much
k. In the mid and high attitude, the compost will be prepared and ready for use; and application is in 3-4 and 4-5 months, respectively.

II. The pit or underground method

a. Prepare two pits with: width 2m, depth 1.5m and length of 4 meters
b. Following the above procedures, fill the heap layers; make sure the one of pits is filled.
c. After a month move the compost from one pit to the other in order to mix it up and decompose it uniformly.